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Dynamo Telegraph Plants. WE publish a short but interesting article in this issue on the dynamo telegraph plant in Chicago, which appears to be following laudably in the footsteps of New York and Pittsburgh in the development of the system. It is evident that sooner or later all the large telegraph offices will find it economical and convenient to place themselves on this basis of operation.

Pathways of Peace. THE paper presented by Mr. H. W. Pope before the National Electric Light Association, entitled "How our paths may be made paths of peace," is a timely contribution to the literature of practical electricity. Mr. Pope indicates the manner in which many of the troubles now endured may be alleviated or removed, and suggests various remedies for evils that some have been inclined to look upon as incurable. A paper of this kind is valuable, too, not only for the ideas that it offers, but for the stimulus it gives to thought and work in the direction of perfection, which must always be striven for, despite our persistent consciousness of shortcoming and imperfection.

Mr. Webb on Submarine Cables. The paper that we publish this week by Mr. H. L. Webb, on submarine cabling, read before the New York Electrical Society, is a most able and interesting production. Mr. Webb has seen a good deal of service in the department named, and has in this paper not only given a brief and extremely graphic account of the manner in which cables are made, laid and operated, but has interspersed the narrative with some very amusing and instructive details from his own experience. One of the most interesting parts of the paper is that in which he tells how the contour of the submarine floor is determined so as to secure the best bottom as the cable's resting place, and how much of skill and ability is found to be necessary in the arduous work of cable repair.

Insulated Scaffolds Wanted. THE operative painters of this city have, it is worthy of note, appointed a committee to draft a bill for presentation to the Legislature, requiring that "boss" painters shall provide proper swing scaffolds with guard rails or ropes around them. The painters say that more lives are lost annually in this city by falls from painters' scaffolds than by electric wires, yet the subject attracts much less public attention, because it has been nobody's special interest or business to magnify and misrepresent the subject, or to work up the public fear into a frenzy with the help of the daily papers. Favoring, as we always have done, the use of all the best methods in every industry for promoting the safety of human life, we hope that the painters will get their insulated scaffolds.

Local Rule for Electricity. IN an interesting paper read last week before the Boston Electric Club, Mr. Lord made a forcible argument against the overdoing of legislation in regard to electrical wires and applications. Certainly one of the perils to electrical advance to-day is the rabid desire in some quarters to subject the art to all manner of limitations. We can heartily approve and echo his words to the assembled electricians: "If you do your part, then it will not be difficult to satisfy the people that much of the legislation proposed by the alarmists is not only unnecessary but unwise. It will be no small service to the state if it is shown even in a single department of human activity that the public can be wisely and safely served without a continual resort to legislation, and that elsewhere than in statute law can be found a remedy for some, at least, of the possible dangers to property and life."

Control of the Lighting Subways. THE past month has seen an active struggle for the control of the new lighting subways in this city. The sub-contract that has been proposed would practically vest the control in the hands of the Westinghouse interests, and this has naturally been objected to for quite other reasons than the one that the Subway Company has no power thus to release itself or be relieved from part of its contract. While it is only proper that if Westinghouse capital is ready for the enterprise it should be given the opportunity, it is not less natural that companies operating under other auspices should prefer not to be placed in the position of asking for their rights at the hands of business rivals and competitors. In short, it seems desirable that the Subway Company should do its own work, with the aid and support of al the local companies, and we hope yet to see some such arrangement carried through.

Telephone vs. Electric Railway. IN our last issue we made brief note of the decision rendered by Judge Taft at Cincinnati in the suit brought by the telephone company to restrain the electric railway there from employing the single trolley system of overhead conductors. As reported at that time, the court has decided in favor of the telephone company, but the importance of the point at issue and the adverse character of the decision, thus differing from some of those previously rendered, warrant us in printing it in full. Judge Taft is evidently of the opinion that the telephone, having occupied the ground first, is entitled to its continued possession, and that the burden of overcoming the difficulties complained of lies with the railway company. The application of the complete metallic circuit, or the McCluer common metallic return, although acknowledged to be amply sufficient to afford the desired relief, are not insisted upon by the judge, who, viewing the question from the standpoint of "vested rights," holds the telephone company to have, as it were, a prior right to the use of the earth. As our readers are aware, the majority of decisions in such cases as the one cited have been in favor of the electric railway, and it is to be hoped that an amicable understanding may be reached in cases which may arise in the future. The present decision is to be appealed.

Municipal Lighting Plants. DR. AMORY, of Boston, in a recent paper has taken occasion to deal very thoroughly with the questions involved in municipal ownership of lighting plants. "There seems to be," he says, "in the minds of the public an opinion that illuminating companies are pirates which prey upon the purses of the community, endeavoring to take every advantage of a supposed monopoly to make an exorbitant rate of profit." From this springs the idea that the remedy is to be found not so much in control by supervision as in a transfer to the municipality of the right to supply light, so that the community by way of lower taxes may enjoy some of the fabulous profits that are now assumed to flow from the private monopoly. Dr. Amory takes the trouble to analyze the lighting business in New England, and shows that the rate of profit on the investment is not to exceed four per cent., and he reasons that it will not pay a city government to go into such a business. One of the best established economic facts is the expensiveness of official management, whether by a state or by a smaller community. Beyond this, however, are the weighty arguments against diversion of taxation, the creation of office-holders and the repression of private and individual enterprise. We think, with Dr. Amory, that much of the public clamor, often worked up for a specific purpose, may be silenced by better service, by concession and conciliation within bounds, and by a demonstration of the truth that the business only asks for fair returns.

Underground Work in New York. WHATEVER questions may be occupying the attention of the electrical engineer at the present time, there is none which exceeds in importance or prominence that of the methods of distribution for all classes of service underground. As much has probably been written and said upon this subject in recent years on this side of the water as upon any other subject discussed in electrical circles, but we must admit that until quite recently but few satisfying facts were brought to light. One or two cities, however, have undertaken to supply the necessary receptacles for the underground wires, and New York has notably attracted the attention of the country by its attempts in this direction. It is, therefore, eminently timely and proper that the electrical profession, especially, should be placed in possession of reliable information regarding the present extent and condition of the underground work in New York City, and the paper read by Mr. William Maver, Jr., before the American Institute of Electrical Engineers at its last meeting, will go far toward furnishing this much desired knowledge. The early decision of the Subway Board not to restrict the form of conduit to any particular type resulted, at the outset, in the laying down of a number of different styles, embodying various ideas; and though none of the conduits, it may be said, have yet been in use a sufficient length of time to permit of final judgment, the experience thus far gained will, it appears, avoid the repetition of errors. As Mr. Maver shows, success up to this point has chiefly been attained with conduits consisting of wrought-iron pipes either surrounded by, or lined with cement; and also with a cast-iron conduit; and it would seem that a duct system of some kind best fulfills the conditions and requirements of our streets. But what the reader will probably be most interested in is the record of the circuits actually placed and working as conductors to-day. These facts must evidently be the touchstone by which the success of any underground system is to be judged. They involve, of course, the nature of the insulation and the mechanical protection of the conductor, and upon this point Mr. Maver's paper gives some interesting and valuable information. But with the records he cites of the prolonged successful operation of high-tension circuits in some of the conduits, a more favorable view must be taken of this subject than we were hitherto bound to accept; and these results we are glad to note are due, in not a little measure, to the improved product of our cable manufacturers, and in the second place to the careful jointing which has been shown to be absolutely necessary. But with all this array of facts before us we are, nevertheless, justified in saying that the results thus far obtained, though encouraging, cannot by any means be taken to be final. Underground work in cities is subject to so many conditions, mostly adverse, that one year's, or even three years', successful operation is not sufficient for final decision, though it may aid to a considerable extent in such a judgment. We believe, indeed, after a close examination of Mr. Maver's paper, that no one recognizes this better than himself, and that a paper on the same subject written five years hence may possibly have to record many changes from present practice. This is to be expected, and if the present methods adopted lead to development of a perfected system the conduits of to-day will not have been built in vain. In the meantime, let us all derive new hope and encouragement from the fact that in New York so many high-tension conductors are now working well underground, supplying a large number of arc lights and about 50,000 alternating incandescent lamps.

The New Dynamo of the Canada Electric Company, Limited.

The accompanying illustration shows the incandescent dynamo of the Canada Electric Company, Limited, of Amherst, Nova Scotia, the only electrical manufacturing company in the maritime provinces, and. we think, the only makers of a purely Canadian incandescent dynamo in the Dominion.

The dynamo is of the direct current multipolar type. The advantages claimed for it are absence of joints in the magnetic circuit, low speed as compared with the usual two-pole dynamos of the same capacity, and exceptionally low resistance of the armature, which enables the machine to maintain a practically constant E. M. F. under widely varying loads without shifting brushes or altering the resistance of fields. The armature is of the drum type, the coils embracing about one-quarter of the circumference. The commutator

New Dynamo of the Canada Electric Company.

is made of the best hard bronze, and either two or four sets of brushes are used, according to the manner of connecting up the armature. There is no external magnetism noticeable while the machine is running, the lines of force being directly concentrated on the armature. The dynamo runs perfectly cool under its full load, and owing to the perfect fitting of the bearings and low speed at which it is run, an accidental failure for a few minutes of the oil to feed it entails no serious consequences. The company are using their own make of dynamo in their own lighting station for commercial purposes, and have furnished Messrs. A. Robb & Sons, of Amherst, for their foundry and machine works, a 100-light plant; also Messrs. Rhodes, Curry & Co., of the same place, with a 50-light plant for their wood-working factory. They also run a motor current, furnishing motors of their own make, two of which are used by newspaper offices in the town to run their presses. The company are young, but have reason to feel much encouraged, and look for a good business in incandescent lighting, both for commercial and isolated purposes, as well as in furnishing general electrical supplies.

Mr. T. H. Griffin is president; Mr. J. Hearle Wagstaff, secretary, treasurer, and manager; and D. M. Bliss, electrician. To the latter is due the credit of designing the machine. Our illustration shows the latter without the sliding base with which it is usually provided.

A Church Plant Operated by a Shipman Steam Engine.

We illustrate on this page an electric light plant which has been installed in the Universalist Church, Fitchburg, Mass., the power for which is furnished by a Shipman engine using oil as a fuel. In the church are fifteen 32 c. p. incandescent lamps, six 25 c. p. lamps, and five 16 c. p. lamps, run from a dynamo, and which are giving entire satisfaction. The Shipman engine is specially adapted for use where small isolated electric light plants are desired, as no coal is necessary, and almost no attention required.

The Shipman engine is an automatic steam engine and boiler complete, using kerosene oil of a low test, or natural gas, for fuel, and is designed for users of a moderate amount of power. Its essential points are that it is so thoroughly automatic in fuel, water-supply and speed, that when steam has been raised, little, if any, further attention is required beyond that of opening or closing the throttle-valve when the engine is started or stopped. In burning the oil no wicks are used, and there is nothing to gum up or clog. The fire is formed by a mixture, in proper proportions, of steam and oil. This is fed through one or more atomizers, according to the size of the boiler. A supply of steam from the boiler passing through these atomizers carries with it into the fire-box, in a fine spray, just the amount of oil necessary to generate steam for the work being done by the engine. As the oil enters the fire-box it is ignited by a torch, and the combustion is so perfect that there is little or no smoke; so the full value of the heating qualities of the oil is obtained.

The amount of steam and oil used by the atomizers is controlled by an automatic diaphragm valve, located in the steam-pipe between them and the boiler. Through this diaphragm, the mechanism of which is simple, and to which easy access can be had, the steam passes on its way to the atomizers; and, as the pressure of the steam in it becomes greater or less than the tension of the spring which governs it, a valve attached to the diaphragm plate is made to close or open, and thus regulates not only the amount of steam and oil being consumed, but also the pressure in the boiler. In this manner the fire is increased or decreased, according to the load on the engine, and the steam pressure is at the option of the user, and can be varied by him almost instantly.

If the engine is stopped the fire is entirely put out by the diaphragm; but upon starting again, the fire at once relights itself, the steam pressure having been held in the meantime by the automatic action of the diaphragm, which will have allowed just enough oil to be burned to make up for the loss of steam by condensation. The supply of oil is stored in a tank placed at any convenient distance from the boiler, and is led to it by ordinary piping.

The boiler consists of a hollow, oblong back, constructed of steel and thoroughly stay-bolted. Into one side of this back are screwed lap-welded wrought-iron tubes 1¼ inches in diameter and 13 inches in length. These tubes are closed at the outer end by a welded plug. This makes a very compact and quick-steaming boiler, gives large heating surface and insures safety, it being almost impossible to explode one so that it will do harm. The boilers are tested by a hydraulic pressure up to 400 pounds. As a matter of record, steam can be raised on a 4 h. p. boiler from cold water to 100 pounds pressure in ten or twelve minutes.

The water supply is effected by a plunger feed pump run direct from the engine shaft, and is kept at a uniform level in the boiler by means of a float connected to a valve in the suction of the pump. This float is in a chamber which is connected by piping to the top and bottom of the boiler, and rises and falls with the water. The movement is conveyed by levers to the valve in the pump, which it opens or closes as the water level changes.

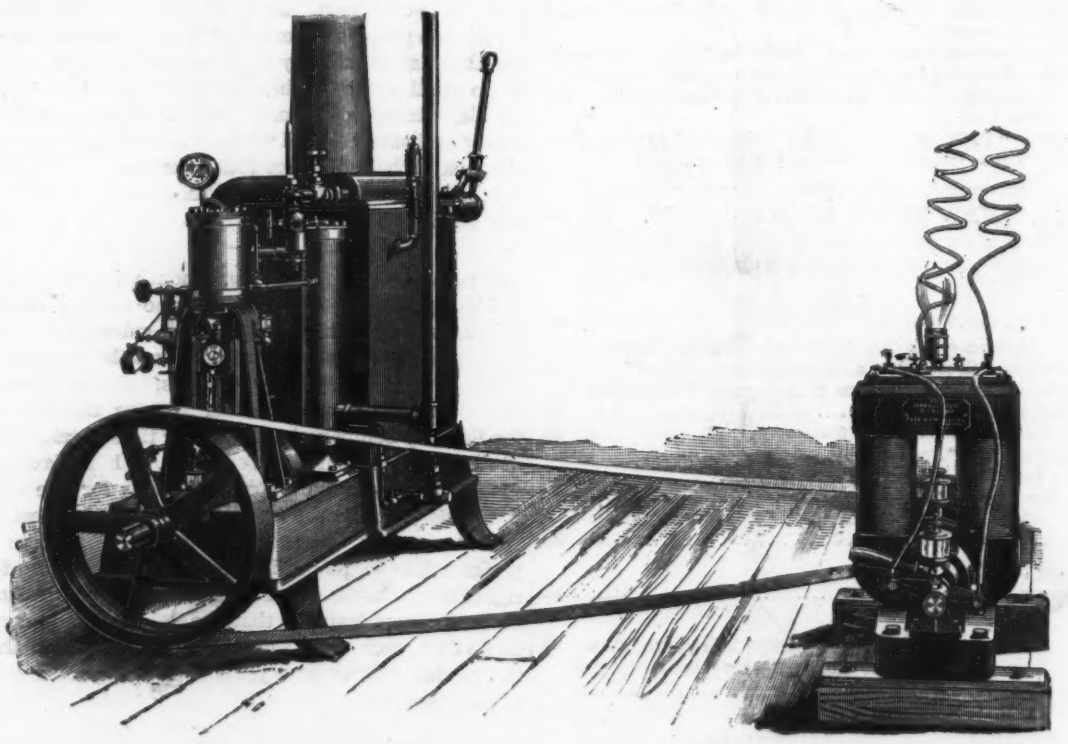
The engine is well built, and of the best material. The piston is solid, and has sectional packing rings, each section overlapping the other, and being set out by independent springs. This, of course, makes a very tight and true-wearing ring.

The valve is of the piston type, and perfectly balanced. The governor is of the automatic cut-off type, working direct from the shaft to the valve, and the speed is very finely regulated, no matter what the load. The shaft is of cast steel, very large, and having extra long bearings in babbitted boxes.

All wearing parts are of extra size, and adjusted for the taking up of lost motion. Lubrication of the cylinder is by a sight-feed, and of the slides and shaft boxes by the ordinary oil cup. Oiling of the crank pin is effected by a centrifugal oiler attached to the crank disc.

From the above it can be seen that when steam has been raised, and a sufficient quantity of oil and water supplied, the engine requires no further attention.

When there is only cold water in the boiler, in order to operate the fires, a hand air-pump, attached to the boiler, is provided. A few strokes of this pump will start the fires, and it is only necessary to pump slowly for seven or eight minutes to raise steam enough to keep them going. As soon as steam is made, all work with the air-pump ceases; and, as before stated, 100 pounds can be raised in from ten to twelve minutes. As regards the other advantages of the Shipman engine, it can be said that it is compact, light and durable, and entirely dispenses with the services of a skilled engineer.



A Compact Plant for Church Lighting.

The Electric Lighting Plant of the City of Marquette, Mich.

Marquette some time early last year determined on supplying its citizens with electric lights from a plant to be owned and operated by the city, and at a minimum cost to the consumer. To this end the City Council wisely determined to select from among its prominent citizens a "Lighting Board," consisting of five members, each one of whom was well known and recognized as thoroughly honest and practical, and possessing in a large degree sound common sense; and it placed in the hands of this board full authority to work out to a completion any scheme adopted by them having in view the supplying of the people with electric lights, both arc and incandescent, and at the lowest possible cost consistent with good service.

At a distance of 19,800 feet from the centre of the city, an unimproved water power on Dead River had existed from time immemorial, consisting of a series of falls and rapids, extending about one and a quarter miles in length along the stream. To purchase this was the initial step, and for the consideration of $10,000, 400 acres of land situated on both sides of Dead River, and including the rapids and falls referred to, and the necessary acreage required for flowage, was accordingly secured by absolute title in fee simple.

A conservative estimate of the water power capable of utilization during the dryest month, within the limits of this purchase, is from 1,700 to 2,000 h. p. It is thought that about 500 to 700 h. p. will be ample for the entire electrical requirements of the city for many years to come for lighting, street car propulsion and transmission of motive power generally. The utilization of electric generators and motors for use at the water works in place of steam is now under consideration, and unless some, at present unforeseen, difficulty presents itself, the probability is that another large expense to the city will be saved in this direction.

Following the purchase of real estate came necessarily the construction of the dam and buildings. The dam has a total length of 200 ft., is built on solid rock, and on the edge of a natural fall, so that while the dam is only from 4 to 7½ ft. high, a head of water is obtained of 28 ft. A flume 14½ ft. wide, 9 ft. high, and 105 ft. long, set on solid stone abutments 12 ft. above the tail race, conveys the water to an inlet iron pipe or tube, and connected with the wheel case and outlet of the draft tube. The case is 5 ft. in diameter, the draft tube 50 in. in diameter, in which are two 40-in. Leffel twin water wheels, with a combined capacity of not less than 350 h. p., and furnished with automatic governors insuring uniform speed.

The buildings erected consist of wheel-houses, 16 feet by 22 feet, 14 feet by 21 feet; and the station 32 feet by 40 feet; all connected together and specially arranged for their respective purposes. The station is very neatly arranged and has plenty of space for the lighting machinery. A line shaft extends the entire length of the station to the pulleys, on which are belted the electrical apparatus now owned by the city, consisting of two No. 8 Brush arc dynamos, each with a capacity of 60 to 65 arc lamps of 2,000 c. p. capacity each, and one Westinghouse alternating current dynamo, with a capacity of 750 lamps of 16 c. p. each.

Besides the dynamos and lamps, there are the necessary governors, regulators and controllers, meters and other electrical appliances.

The electrical plant was contracted for by the Board, after the most severe and critical examination of the several systems. All the reputable manufacturers were represented, and their bids duly presented and considered.

The award for arc lighting apparatus was made to the Brush Electric Company of Cleveland, O., through their

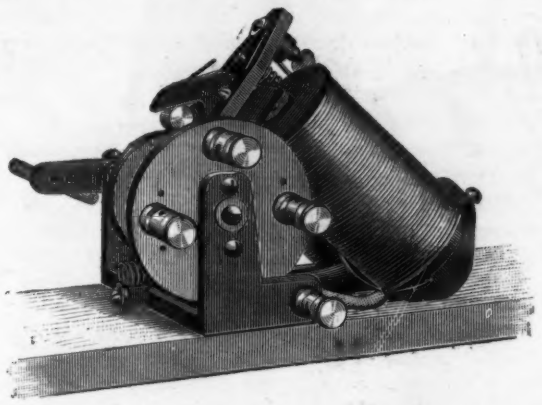
Chicago agency, and for the incandescent lighting to the Keystone Construction Company, of Chicago, for Westinghouse alternating current apparatus.

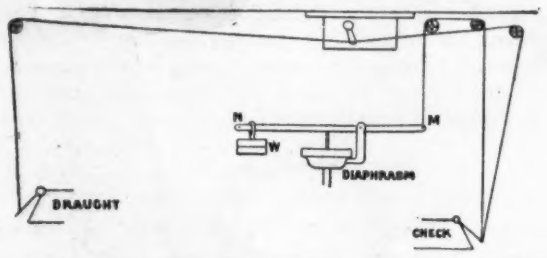
How well both contracts have been filled the citizens can judge for themselves. The plants are accepted, and settlements have been made with the two companies. Not a single unpleasant word has passed between the board and the contractors. The work has been done honestly, the apparatus furnished fully up to the requirements, and the results in both arc and incandescent are entirely satisfactory to the board, to the city, and to the contractors.

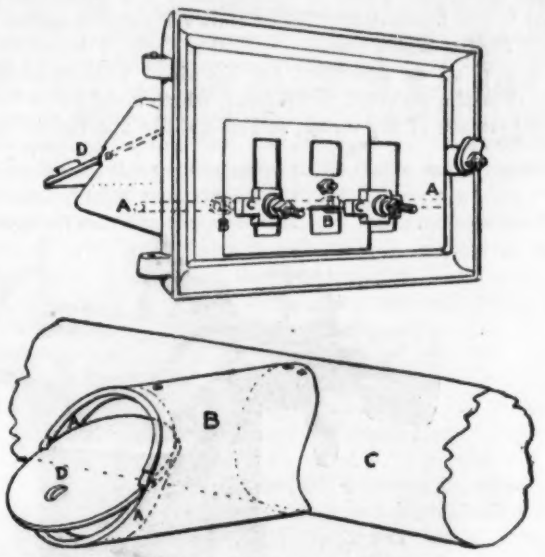
The distance of the power from the lamps was so great that much doubt naturally was entertained as to the final success. The arc circuits are about 18 miles long. The feeder for incandescent lights is nearly 20,000 feet, connecting with about seven miles of mains. The loss in the entire system at full load is about 12 per cent. The total outlay is less than $50,000. This indebtedness is represented by an issue of bonds, bearing 5 per cent. The record for the month of January last shows a surplus of $135, after providing the interest on bonds, paying all operating and other necessary charges, and furnishing the city with its street illumination, and the citizens with their lights at, it is claimed, only a nominal price.

All honor in this connection is due to the Lighting Board, of which J. M. Longyear is the president; Jas. Russell, secretary, and J. M. Wilkinson, treasurer; C. E. Moore and Wm. H. Green, being directors, and to the Mayor of the city, Hon. F. O. Clark, for the care and thoughtful consideration and personal interest shown.

In the language of an agent of one of the contractors, "it is an honest deal; honestly made and executed by honest men, with honest men." How rarely this can be said in municipal affairs. It will now be in order to change the name of "Dead" River to "Living" River.







FIGS. 2, 3, 4 AND 5.—NEW METHOD OF AUTOMATIC ELECTRIC HEAT REGULATION.

A Simple and Practical System of Automatic Electric Heat Regulation.

The use of electricity for regulating temperatures, though a novelty to the general public, is certainly not new, for no better results are obtained to-day than in 1850–1855; but here, as nearly everywhere else in electrical matters, the advance has been in means to be employed in attaining well-known results. Pioneer scientific investigators accomplish in their laboratories, with costly and complicated devices, results which later, in the hands of the mechanic, by simpler methods, become useful and valuable adjuncts of every-day life.

Generally speaking, heat is supplied from combustion, and may be regulated by controlling the supply (as in excluding steam from a radiator or shutting a register in a hot-air pipe), or by controlling the combustion; and this last may be done in two ways: (1) by varying the quantity of material consumed, as in turning up a gas jet and putting fuel on a fire; or (2) by governing the supply of oxygen to the burning material, *e. g.*, by using draughts and dampers in the ordinary way. Circumstances must determine what method of regulation to use.

In dwellings and moderate sized buildings, heated by hot air, hot water or a small steam boiler, it is usual to regulate with draughts and dampers, unless the heater use some gaseous or liquid fuel, as natural gas or petroleum, when it is proper to control the supply of such material. In extensive high-pressure steam heating plants, the steam is admitted or excluded from each radiator, according to the temperature of the space heated by it.

A heat regulator, then, must have some contrivance to detect variations of temperature, and some power at hand to be properly applied to operate valves, draughts or dampers, so as to correct such variations. The regulators of 1850–1860 are complicated, delicate electric devices, used indirectly in connection with operative weights, springs and pressure mechanism to control the sources or supply of heat, and later inventors have been content to elaborate these same methods.

The system described in this article is a radical improvement on these devices, and only as such can it claim attention. As the result of over ten years' study and practical tests, it abandons all indirect sources of power. Electricity is the life and energy of the system, which entitles it to be rightly called "automatic electric," in that it requires nothing but electricity to make it absolutely self-operative.

Its several parts are, a mercurial or metallic thermometer, arranged to make electric contacts whenever the temperature varies from a given degree, which is technically called a thermostat; a four-cell battery of the ordinary open circuit, sal-ammoniac zinc-carbon type; a small electric motor of the familiar rotary armature type; or of a specially designed "ratchet" form, which is geared to a short rotary shaft, which shaft bears at one end a crank or other device suitable for moving valves, draughts and dampers, and at the other end operates a current switch, which from its shape is called a "disc" switch.

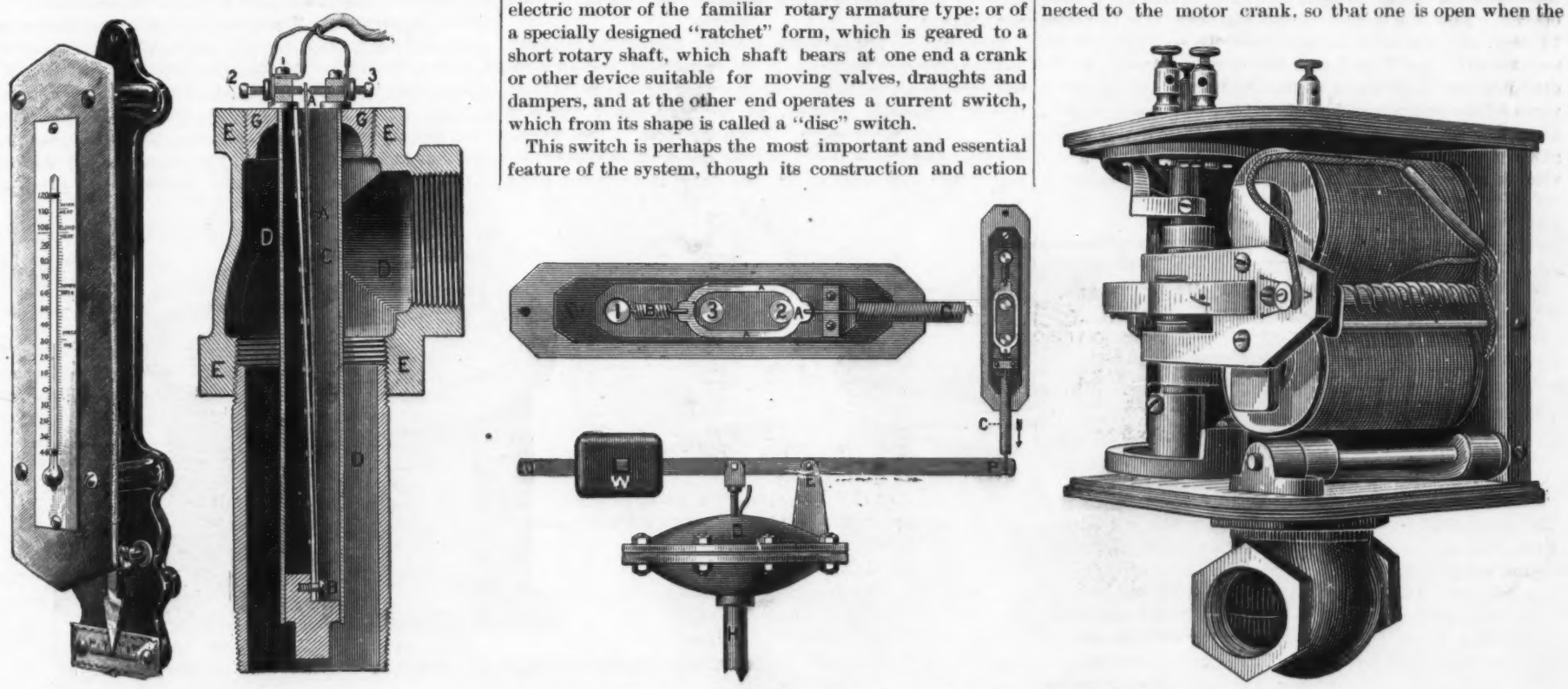
This switch is perhaps the most important and essential feature of the system, though its construction and action are too simple to warrant special description. To this switch are connected the thermostat, battery and motor, and whenever a contact is made at the thermostat the switch operates, first, to start the motor; then to cut the thermostat entirely out of circuit; then to cause the motor to move independently of any control of the thermostat to properly shift the valves or dampers; when, finally, it breaks the circuit, stops the motor, and puts the thermostat into control again.

It is safe to say that if a furnace fire be governed according to the severity of the weather, so that one room of the house be maintained at an even temperature, other rooms heated by the same fire must also have an even temperature. Some living-room is selected, such as the "sitting-room," and on the walls of this room is fixed the thermostat, shown at Fig. 1, consisting of a front, finished in plush, wood, nickel or bronze, bearing a moderate-sized mercurial thermometer, and concealing a thermostatic (heat-warping) bar of steel and rubber, one end of which is firmly held; the other end plays between two suitable contact screws, and moves to the right or left according as the temperature rises or falls. By means of an arrow and scale, the thermostat may be set to any desired degree of temperature, and whenever the temperature varies slightly from this point the proper electric contact is made. The design shown in Fig. 1 is simply and strongly made, is accurate and sensitive in action, ornamental in appearance, and but slightly indicates its mechanical or electrical nature.

From the thermostat, wires are run to the "disc" switch of the motor, shown in Fig. 2, which is the style ordinarily used, and is an intermitting magnet "ratchet" motor, weighing 10 pounds, and on four cells of battery will raise 15 to 20 pounds of dead weight three inches for each half turn of the shaft. The disc switch used in this device is constructed so that for every contact of the thermostat the shaft will make a half rotation and then come to a stop.

From the crank of this motor chains are run, as indicated in Fig. 3, to two swivel doors, one being shown in detail in Fig. 4, consisting of a box-like casting called the "draught" door, which is clamped to the ash-pit door of the furnace and serves to control the admission of air to the fire.

The other, shown in Fig. 5, called the "check" door, is fastened to the discharge flue, and, when open, materially checks the force of the draught. These doors are connected to the motor crank, so that one is open when the other is shut, and they also balance each other, so that the motor has only to overcome their friction.



FIGS. 1, 6, 7 AND 8.—NEW METHOD OF AUTOMATIC ELECTRIC HEAT REGULATION.

Now let us suppose these parts attached to a hot air furnace and the thermostat set for 70 deg. Fahr. As long as the rooms are too cold, the crank remains at rest holding the draught door open and check door shut, and the fire is livened. As soon as the temperature reaches 70 deg. the crank makes a half-revolution and rests with the check door open and the draught door shut, deadening the fire. When the temperature falls one-half degree, the draught door is again opened, and thus the regulation proceeds from beginning to the end of the year without any supervision.

For hot water and steam heaters a different state of affairs is presented, and the method just described cannot be applied. Something more is necessary, as in a hot water heater, the temperature of the water must be taken into account. If a regulator such as that just described

be applied for hot water, and it be a very cold day, the draught door will be held open continuously. The temperature of the water rises to 210 degrees, and is then distributing all the heat it can through the medium of the water; increased temperature means steam, and steam means that the water will be forced out of the system and the heater becomes useless. Either something must be at hand to check the fire, if for any reason the water gets near the boiling point, or the regulator is a detriment and had better be omitted. Fig. 6 shows a supplementary device for hot-water heaters, and other parts of the regulator are applied as described for hot air. This contrivance consists of a jacketed thermostat, which is subjected to the temperature of the water, and should the apartment thermostat for any reason keep the draught on continuously, so that the water is near boiling, the fire will be checked by the interfering action of this auxiliary thermostat till the danger is over; and if necessary, on a cold day, the water will be maintained at 205 to 210 deg. Fahr. without danger of boiling. Hot-water heaters, otherwise very efficient, are, as a rule, defective in manner of regulation, but this method meets every requirement.

A somewhat similar state of affairs is found in steam boiler heating by low pressure, *i. e.*, not higher than 3 or 4 pounds to the square inch, and when that pressure is obtained the radiators are doing as good work as they would do on 20 or 30 pounds. Suppose a steam boiler has been regulated through the night for 60 deg. In the morning the thermostat is set at 70 deg., and the draughts are at once opened. Now, the temperature of the house is to be raised 10 deg., and this will require much longer time than is necessary to get 3 or 4 pounds steam pressure. If the draughts are kept open continuously till the house is warmed the pressure will attain to 20 or 30 pounds, or even more, and something should be at hand to hold the steam at 3 or 4 pounds while the house is warming. Such a device is shown in Fig. 7. The steam heating boiler is usually provided with a "diaphragm" regulator, which maintains a constant pressure, however much the requirements may vary from hour to hour, which is just what is not wanted. When the house is slightly cold a little steam is needed; when warm enough, no steam at all, and when decidedly too cold 3 or 4 pounds, but no more, is required; and all these variations may occur during the course of two or three hours.

To accomplish these results on steam heaters, the regulator is applied as indicated in Fig. 8 and as described for hot air. In addition, the "diaphragm" lever is left connected with the "check" dampers, and also utilized, as in Fig. 7, to actuate an interfering device, which causes the motor to check the fire if the pressure exceed the amount for which the weight *W* is set, and also acts, in conjunction with the thermostat in the apartment, to maintain that pressure as long as the house is decidedly too cold.

Most satisfactory results are obtained on the three kinds of heaters above noted, and the amount of fuel consumed is almost exactly in accordance with the severity of the season. When the heater uses a liquid or gaseous fuel, two pipes are run to the burner. In one pipe is placed a hand valve, which is permanently opened only sufficiently to maintain a small flame at the burner. In the second pipe is placed an electric valve, which is controlled by a thermostat, and is either full open or completely shut, causing the intensity of the flame to vary according to the changing temperature, and limiting the quantity of fuel burned to that actually required. Fig. 8 shows a valve which may be used for this purpose, but which is more particularly adapted to be used with a thermostat for temperature regulation of high-pressure steam. Its construction is sufficiently well indicated in the cut. A motor is geared to a shaft, which bears at one end a cam for opening and shutting a valve, and at the other end is a "disc" switch of a little different construction from the one shown in Fig. 4, but performing similar duty. The valve proper is of ordinary construction, a globe-valve of the Jenkins patent. The steam pressure is admitted above the valve, and prevents any leakage by holding it firmly to the seat when the valve is shut. Three styles, straight, angle or corner, are made in three sizes, ¾ inch, 1 inch and 1¼ inch, and will operate under any ordinary attainable pressure, 100 to 150 pounds, using four cells of ordinary open circuit battery. A number of valves can be operated by one battery, which is used in common, as in the case of electric gas lighting.

In regulating high-pressure steam, a thermostat is placed in the apartment heated by a coil or radiator, and an electric valve is placed in the corresponding steam supply pipe. If it is a two-pipe system, an ordinary check valve is placed in the return pipe. When the room is too warm, the electric valve is closed and the check valve shuts automatically by pressure, so that the steam is excluded from the radiator, and when the room cools slightly the steam is admitted again. Thus the steam supply to each radiator is governed by the temperature of the space it heats.

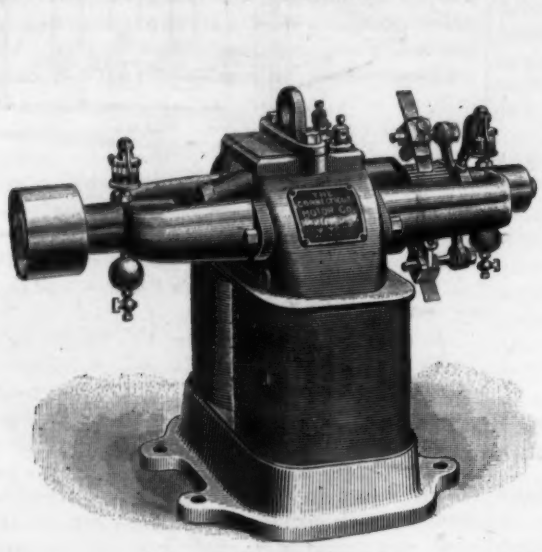
It is not necessary to describe details of construction, nor to enlarge on the advantages of heat regulation in general, nor to point out many other obvious uses for such appliances, which are as numerous as are the uses of valves, draughts and dampers.

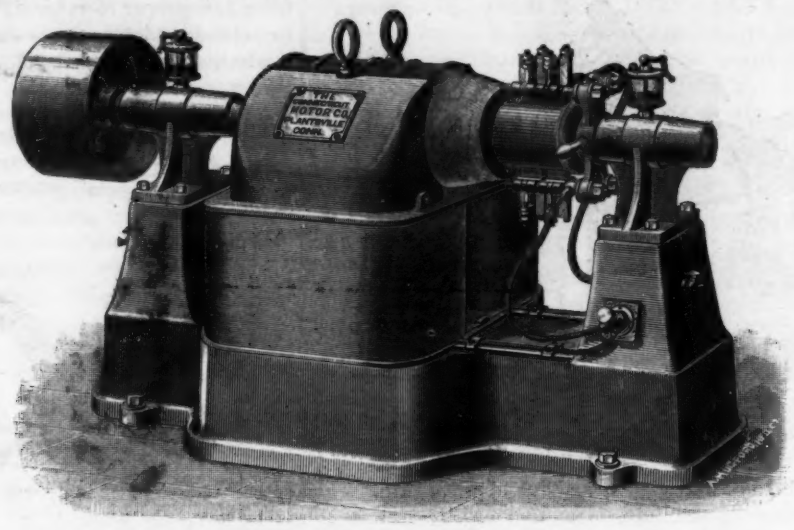
As all electricians know, by sad experience, open-circuit batteries do, sometimes for no apparent reason, get short-circuited and spoiled, and this is the weakest point about any appliance using such batteries. This short-circuiting or grounding is guarded against in the various regulating systems above described, by the use of a very simple and comparatively inexpensive cut-out, which is automatic and sure in its action, and acts to break the circuit completely if it be maintained continuously longer than about 30 seconds. This cut-out is manufactured by a firm in Syracuse, N. Y., and insures the life of the battery, however badly managed, for an indefinite time, meanwhile saving, by avoidance of renewals and recharging, many times its own cost.

The apparatus above described is manufactured by Mr. F. M. Sparrow, of Boston and Mattapoisett, Mass. It is strongly and simply made, and absolutely automatic in its action, and easily applied.

The New Connecticut Electric Motor.

The steady demand, which is constantly on the increase, for motors of large powers is causing the manufacturers of this class of apparatus to devote special attention to such work, and among these the Connecticut Motor Company, of Plantsville, Conn., has been keeping pace with the requirements. The type of machine heretofore built for smaller powers is illustrated in the engraving, Fig. 1, while the recent demand for larger powers has resulted in the design of the machine illustrated in Fig. 2, which has been adopted for motors of 7½ h. p. and over.



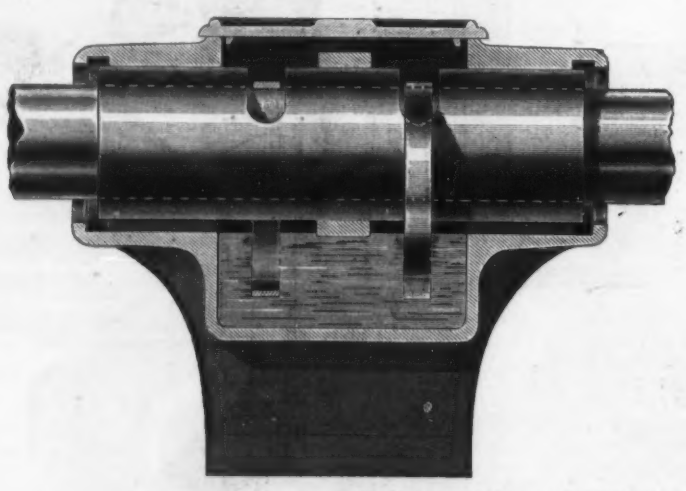


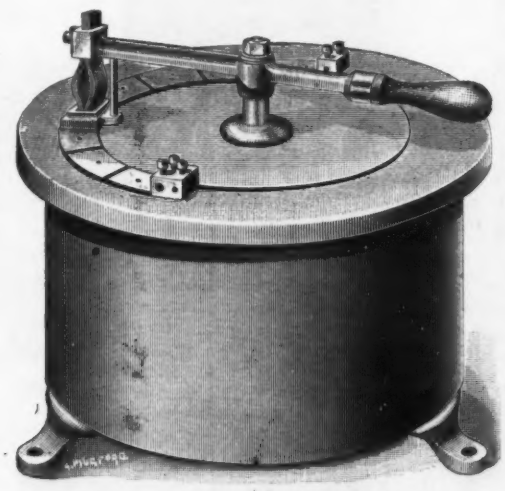
FIGS. 1 AND 2.—THE CONNECTICUT ELECTRIC MOTOR.

It will be observed that the new design is an extension of the older form, the change being of a mechanical and and not of an electrical character.

We are informed that this change would not have been made in motors under 10 h. p. but for the demand which the company experiences for small generators for isolated incandescent plants, for which work, as for heavy motors, the pillow-block pattern has been considered desirable, as affording greater stiffness, with more room for commutator, brush-gear and bearing boxes. The engraving, Fig. 3, is a sectional view of the self-lubricating bearings with which these machines are fitted. This style of box, though in itself by no means a novelty, has been ingeniously applied to long bearings by duplicating the lubricating rings, and thus incidentally obtaining an increased oil capacity.

The bearings of the smaller motors from ¼ h. p. to 5 h. p. are either of the Graphite Lubricating Company's design, or fitted with grease cups, both of which methods have given satisfaction. These motors are all plain shunt wound for constant potential circuits. The massive magnets yield a powerful field, and admit of armatures having proportionately low resistance. The starting box, shown in Fig. 4, is entirely separate from the motor, the company considering the extra cost entailed thereby to be far preferable to even the most condensed design of motor and rheostat in one. These boxes are built of slate, iron and asbestos, and are absolutely fire-proof, even in the hands of the janitor, who knows that every box having stops upon it *must* be a regulator.





FIGS. 3 AND 4.—DETAILS OF THE CONNECTICUT ELECTRIC MOTOR.

The Massachusetts Mechanics' Charitable Association will hold in Boston during the coming Autumn their seventeenth Triennial Exhibition of Industry, Skill and Art. It is expected that electricity will play a large part in this show. Mr. A. Bicknell is the secretary.

The "Black Giant" Portable Storage Battery.

The use of the storage battery for the various purposes of cautery, nasal surgery, faradisation, and as a source of current for small incandescent lamps, is constantly on the increase among physicians, and especially so since the storage battery enables the physician to carry about with him in convenient form a comparatively large current capacity. One of the latest forms of portable batteries designed for this purpose is that known as the "Black Giant," manufactured by Messrs. Meyrowitz Bros., of this city. The accompanying engraving, Fig. 2, is a sectional view of the cell, showing the arrangement of the plates.

FIGS. 1 AND 2.—"BLACK GIANT" PORTABLE BATTERY.

Each cell contains eight storage plates, which radiate from the centre and are secured in such a manner that buckling and consequent short-circuiting is made impossible, and the battery is entirely free from local action. The plates are suspended from a heavy hard rubber disc which, being screwed into the top of the cell, seals it completely and prevents spilling of the fluid and corrosion of the terminals and connections.

The capacity of each cell is over 30 ampère hours, and the rate of discharge may be from 1 to 20 ampères. The electromotive force of each cell is over two volts. One cell is sufficiently powerful for cautery work, while two cells will run a one-eighth horse power electric motor for four hours or light a two-candle power incandescent lamp for 15 consecutive hours.

The cell, together with a rheostat, is shown complete in Fig. 1, which illustrates the general type of apparatus. A larger size, containing two storage cells, is also made.

Cooley's Improved Wire Stretcher.

It has frequently been remarked that much of the best overhead insulated wiring is seriously depreciated by the rough handling which it receives in its erection on the poles, and the use of the ordinary hand vise as a wire stretcher is often to blame for this. To remove this source of trouble, therefore, Mr. C. A. Cooley, of Montreal, Quebec, has devised the insulated wire stretcher illustrated in the accompaning engraving. As will be seen, it consists of an open ring of metal about six inches in diameter, having small flanges on each side and a clamp for holding the wire; it is also fitted with a link or clevis to receive the usual lineman's strap. The wire to be pulled up is given one or two turns around the ring and then loosely clamped. The wire may then be strained to the breaking point without injuring the insulation in the least, the strain being distributed over a comparatively large surface of the wire wrapped around the ring.

The tool is very light and will prove valuable in line construction, as it leaves the wire in good condition, unlike the hand vise, now in general use, which is very destructive of the insulation.

The Fisher Automatic Dynamo.

A new form of an automatic incandescent dynamo recently placed on the market by the Fisher Electric Company, Detroit, is illustrated herewith. As shown in the engraving, the dynamo is a single field machine, the shunt coil being placed below the armature, as shown, and the regulating coils wound on the pole pieces embracing the armature. Rheostats and other hand regulators are entirely dispensed with.

The machine rests on a strong oak base that is mounted on a heavy cast-iron bed plate, with felt tightener attached. The shaft bearings are supported by heavy cast-iron projections, bored concentrically with the pole pieces, and secured in position by heavy clamping nuts that encompass the cast-iron extensions upon the bearings, firmly holding the upper part of the machine. The bearings proper are made of small brass babbited cylinders.

The brush-holders are supported in the usual manner. The brush yoke, however, is cast on the front box, and is held rigid in one position; it cannot be moved in either direction. This arrangement dispenses with all clamping and adjustment screws, and simplifies the machine greatly. The tension springs controlling the brushes are placed in a tube thoroughly protected from mechanical injury, and when tension is once applied they cannot be tampered with. The terminal connections are all made on a hard wood base that is covered with a second hard wood plate, exposing only the line binding posts.

All the parts of the dynamo are interchangeable and of the highest grade of mechanical perfection, while the aim of the manufacturers has been to produce a machine that will be simple, strong, reliable and easily understood.

On the Importance of Removing Scale from the Interior of Boilers.

BY MARTIN VAN BUREN, M. E.

Removing scale from the interior of a boiler is known to be a matter of vital necessity not only for the saving in fuel, but also the great danger of explosion consequent upon such incrustation.

Nearly all waters contain foreign substances in a greater or less degree, and although the amount may be small in each gallon, it becomes a matter of great importance when large quantities of water are evaporated.

COOLEY'S WIRE STRETCHER.

The analysis of a great variety of incrustations shows that carbonate and sulphate of lime form the greater part of ordinary scale: that from carbonate being soft and granular and from sulphate hard and crystaline. Organic substances in connection with carbonate of lime will also make a hard and troublesome scale.

The duty of a boiler proper is to transfer the heat generated by the combustion of the fuel into useful effect by evaporating water into steam, and a boiler which evaporates 7½ pounds of water for each pound of combustible utilizes but 50 per cent. of the total heat. This is about the average result of shell boilers now in use.

The main cause of this loss of efficiency and economy in a boiler is the accumulation of scale in the interior.

It is now fully established that all the mystery of boiler explosions consists in the want of sufficient strength to withstand the pressure. This lack of strength may be inherent in the original construction, but it is most frequently the effect of a weakening of the iron by strains due to unequal expansion.

The usual cause of unequal expansions and also of weakening by burning and blistering the iron is the presence of deposit or scale on the heating surface. It is estimated that the presence of $\frac{1}{32}$ inch of scale causes a loss of 13 per cent. of fuel; ¼ inch of scale causes a loss of 38 per cent of fuel; ½ inch of scale causes a loss of 60 per cent. of fuel. The amount expended in consequence of loss of fuel, extra repairs, etc., on a locomotive in the middle and Western States, has been carefully estimated at about $750 per annum, and for the same power in stationary boilers at about a similar amount. All this extra expenditure is due to incrustation.

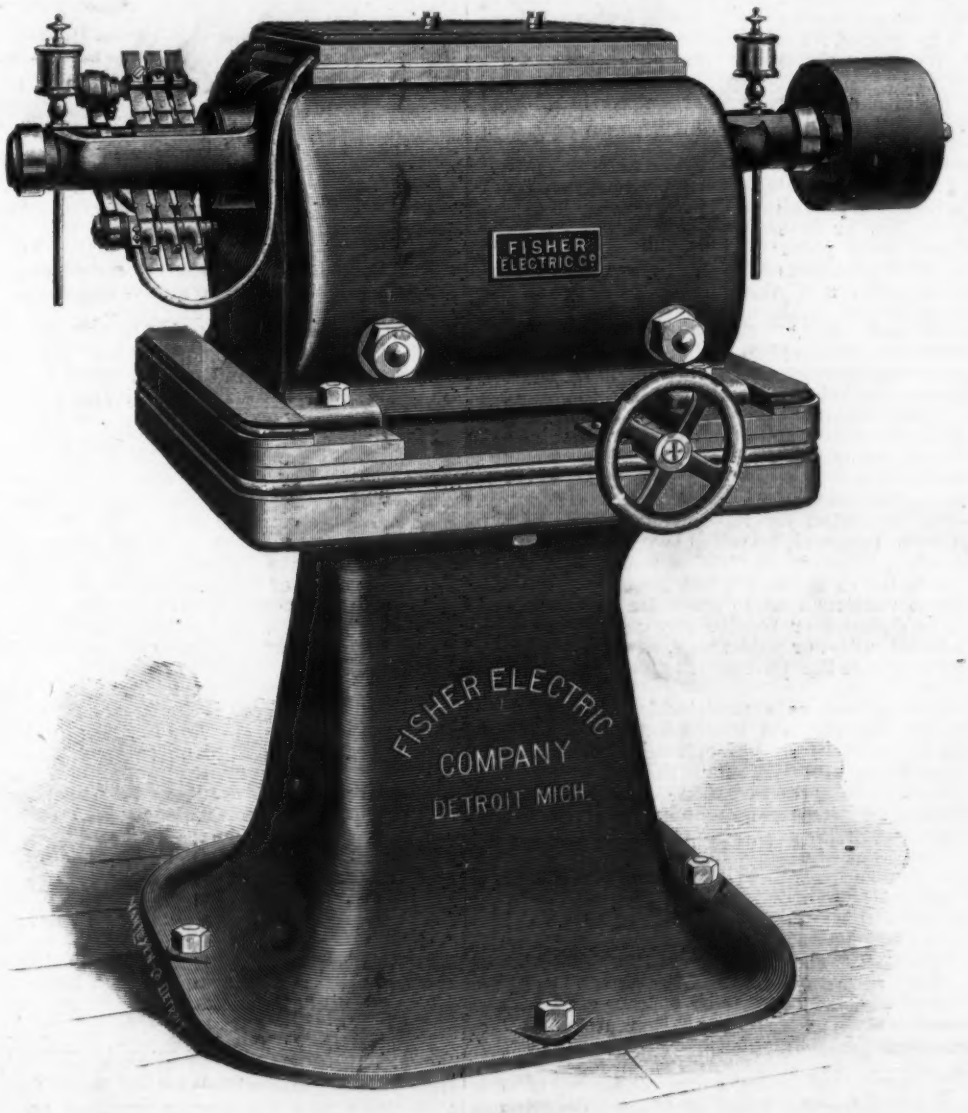
A great number of compounds are manufactured to dissolve the scale by chemicals, such as soda, acids, etc., and when these are put into the feed water of the boiler they render the sulphate and carbonate composing the scale soluble in the water, thereby increasing its density. It is a well-known fact that the temperature of water in a state of ebullition will increase with its density, thus causing an addititional expenditure for fuel and giving rise to prim ing, in itself a source of great danger and serious loss in the engine.

The compound manufactured by the Litofuge Manufacturing Company, of New York, does not dissolve nor disintegrate the scale. Its action is wholly mechanical, consequently all the danger and trouble arising from the dissolution of the scale is entirely prevented by the use of Litofuge. Not only does it remove the incrustation from the interior of the boiler, but by its continued use renders all the salts in solution in the water insoluble, causing them to be precipitated in the mud-drum of the boiler, thus preventing any new formation of scale while the Litofuge compound is in continued use.

A Marriage by Telephone.

Minnie Worley, aged 22, telephone exchange operator at South Bend, Ind., and Frank Middleton, aged 25, in a like position at Michigan City, became acquainted over the wires during their night watches. Finally Middleton proposed in fun that they get married by telephone, and Minnie consented. A Michigan City Justice was called in and performed a legal ceremony, but without the necessary state license. This occurred a week or two ago and passed off as a joke. Now eminent legal counsel pronounce the marriage legal and binding, and say Justice Dibble is liable to imprisonment for performing the cere mony without the necessary license.

The groom will go to South Bend to see his bride, and divorce proceedings will probably be instituted unless they agree to live together.



THE FISHER DYNAMO.

The Taft Decision Against Single Trolleys.

Superior Court of Cincinnati.—The City and Suburban Telegraph Association vs. The Cincinnati Inclined Plane Railway Company.

Taft, J.: This is an action to enjoin the defendant from using a system of electric railway propulsion, known as the single trolley system, in running its cars upon the streets of this city and the roads of the county, because, as plaintiff claims, it does a great injury to the conduct of the public business in which it is engaged, *i. e.*, the maintenance for profit of telephone communication between a large number of subscribers in the city and county. Plaintiff alleges that it has been conducting its business under lawful grants of the legislature of the State and the municipal authorities, and by virtue thereof has lawfully erected many lines of telephone wires on the streets upon which the street railway of defendant is conducted and operated. That the defendant has no lawful authority to use electricity as a propulsive power for its cars; that the single trolley system in use by defendant conducts upon and induces upon the wires of the plaintiff erected on the same streets currents of electricity, which make it impossible to use those wires for the purpose of telephone communication; that the result is, that many of the subscribers of plaintiff have made complaint and threatened to discontinue the use of the telephone, and some have refused to continue payment for the same, all to the great injury of the plantiff; that the damage is irreparable and continuous, and that plaintiff notified defendant before the erection of the single trolley system that it would result in a serious injury to plaintiff, and of the objection to the system.

The defendant answers, denying plaintiff's lawful right to operate telephone lines; avers its own lawful right to conduct a system of electrical railway propulsion; avers that the single trolley system is the only practicable one in use, and secures advantages to the defendant not afforded by any other; that plaintiff's difficulties arise from the defects of its own telephone system, in that, for economy, it uses the earth as a return conductor, and so invites onto its lines many disturbing currents, both natural and artificial, although the mechanism of the telephone is so delicate that any proper system would make the return circuit metallic; that plaintiff's claim amounts to a claim to the exclusive use of the earth as a conductor, which is without warrant of law; that the use by the defendant of the earth as a return circuit is a material assistance in propelling cars up heavy grades; that it could not alter its system so as to avoid the use of the earth as a return circuit except at great outlay and loss of efficiency. The answer denies that the operation of its road produces interference with the telephone lines of plaintiff, and says that, if any injury has been produced for which defendant is liable, the damages are capable of exact ascertainment, because they can all be remedied by an additional expenditure by the plaintiff, and that therefore there is no ground for equitable relief.

Plaintiff, by its reply, denies the allegations of the answer.

1st. The plaintiff company was organized in 1873 as a magnetic telegraph company, to conduct a telegraph business on lines within the city and between here and Hamilton, under laws which have since been incorporated in Chapter 4, Title II., concerning magnetic telegraph companies. Section 3454 provides that "a magnetic telegraph company heretofore or hereafter created may construct telegraph lines from point to point, along and upon any public road, by the erection of the necessary fixtures, including posts, piers and abutments necessary for the wires; but the same shall not incommode the public in the use of such road." Section 3461 provides that "when any lands authorized to be appropriated to the use of a company are subject to the easement of a street, alley, public way, or other public use, within the limits of any city or village, the mode of use shall be such as shall be agreed upon between the municipal authorities of the city or village and the company; and if they cannot agree, or the municipal authorities unreasonably delay to enter into any agreement, the probate court of the county, in a proceeding instituted for the purpose, shall direct in what mode such telegraph line shall be constructed along such street, alley, or public way, so as not to incommode the public in the use of the same; but nothing in this section shall be so construed as to authorize any municipal corporation to demand or receive any compensation for the use of a street, alley, or public way, beyond what may be necessary to restore the pavement to its former state of usefulness."

In 1878, the telephone, as a practicable commercial instrument, came into use, and the plaintiff became the licensee of the American Bell Telephone Company, with exclusive right to use all its patents in this city and county. Before this time, in 1873, the Common Council had passed resolutions fixing the terms under which the plaintiff might occupy the streets with its poles. From 1878 until the present time, the business of the plaintiff has grown to such an extent that it now has over 3,000 subscribers in the city and vicinity. The pole lines of the plaintiff along the streets occupied by the defendant's railway were erected in 1881 and 1882. In 1880, the following section was added to the telegraph law, 3471: "The provisions of this chapter shall apply also to any company organized to construct any line or lines of telephone; and every such company shall have the same powers, and be subject to the same restrictions, as are herein prescribed for magnetic telegraph companies."

The pole lines of the plaintiff are so erected under the ordinance of the city as to leave a bar at the top of each pole, on which to string the wires of the fire department telephone lines. The fire department and police department are each given a separate exchange, operated by city employés. The city strings its own wires upon the telephone poles, but pays nothing to the plaintiff for the use of the instruments, or for the general exchange work of the fire or police department. The poles have been erected at such places as directed by the engineer of the Board of Public Affairs, and under his supervision. The plaintiff has always used the earth as the return circuit. This has been the case with all the telephone systems in this country down to the present day, with the exception of certain long distance lines from New York City, and the connecting subscribers who frequently use those lines in that city. The telegraph companies have used and still use the earth as the return for the circuit. The most complicated part of the telephone business is the mechanism by which temporary connection is made between any two subscribers' lines. It is called a switchboard, and each one of the exchanges, of which there are five in this city, is furnished with one. It is a very expensive instrument, and could not be adapted to use for a system of metallic circuits.

It will thus be seen that every step taken by the plaintiff was authorized by law, and that all that has been done by it has been with the consent of the proper authorities. From this statement, there can be no doubt that the plaintiff has a lawful right to occupy the streets upon which defendant's track is laid, with the poles and wires erected for the conduct of its business, and that the use of the earth as a return is not a violation of its franchise. It was organized and still is called a telegraph company. It began its telephone business before section 3,471 was passed, and, perhaps, some of its poles and lines along the streets occupied by defendant were erected for such use. But this circumstance is immaterial, for it has been held, both in England and in this country, that the telephone system, which is communication over long and short distances through the agency of currents of electricity on metal wires, is really a magnetic telegraph system, and that an exclusive right to operate the telegraph includes the exclusive right to operate telephone lines. Attorney-General v. Edison Telephone Company, 6 Q. B. D. 244. Wisconsin Telephone Company v. Oshkosh, 62 Wis. 32.

Nor does the passage of section 3,471, which expressly makes the chapter on magnetic telegraph companies applicable to telephone companies, affect this conclusion. It was passed simply to remove the basis for an argument, and not because the chapter was not already sufficient to include telephone companies without it.—Chesapeake, etc., Tel. Co. v. B. & O. Tel. Co., 66 Md., 399.

But even if it were true that when the plaintiff company, in 1878, began to use the telephone system it was beyond its charter, it seems to me that the subsequent legislation of 1880 would have validated what before was *ultra vires*. See Spring Grove Ave. Ry. Co. v. Cumminsville, 14 Ohio St., 523.

I have not discussed, in this connection, the question how much the abutting property owners' rights were affected by the erection of the poles and wires of the plaintiff, because their rights are not in issue, and it is to be presumed, from the fact of plaintiff's occupation for so many years, in the absence of other evidence, that if any of the rights of the property owners were taken, they were ceded or sold to the plaintiff.

Having determined, then, that plaintiff's use of the streets on which defendant operates its road is lawful, the next question which arises is, whether defendant has the right to use electricity for the propulsion of its cars. If it has not, and it thereby interferes with plaintiff's franchise, it is very clear that such interference gives plaintiff a right of action. Defendant's counsel seems to contend that the question of *ultra vires* cannot be raised against the defendant in this case; but that such an issue could only be made in an action by the State, or its delegated representatives, to oust the defendant from the exercise of such unwarranted privilege. This contention cannot be sustained, for while it is true that if defendant is violating the limitations of its charter, plaintiff might request the attorney-general to institute *quo warranto* proceedings; nevertheless, it may rely on the fact of defendant's violation of its charter in a private litigation to show that the acts causing loss are unlawful.—City of Zanesville v. Zanesville Gaslight Co., Supreme Court of Ohio, 23 W. L. B. 8.

The larger portion of the line now occupied by the defendant was once operated by the Mt. Auburn Street Railroad Company, under a number of grants from the Common Council, the first of which was made Sept. 2, 1864, and the last Nov. 14, 1873. All these grants were subject to the provisions of the general street railroad ordinance of 1859, that no motive power except horses and mules should be used on any road without the consent of Common Council. The franchise and the property of the Mt. Auburn Railroad Company was purchased by three persons: George A. Smith, J. M. Doherty, and Jos. S. Hill. On April 21, 1871, the Cincinnati Inclined Plane Railway Company was incorporated under the general corporation act passed May 1, 1852, for the purpose of constructing a railroad whose termini should be in Cincinnati and the village of Avondale, and then constructed the inclined plane, still in use, connecting Locust street, Mt. Auburn, with the head of Main street. By ordinance, December, 1871, Common Council gave the company the power to lay tracks on certain streets which connected it with the Mt. Auburn Street Railroad tracks, with the express proviso that no motive power except horses and mules should be used on said tracks. A similar proviso was contained in an ordinance passed Oct. 27, 1875, granting it the right to extend the tracks of the Mt. Auburn Street Railroad tracks to the north corporation line, at the Zoological Garden. In 1876 an act was passed (73 Ohio L. 229), providing for the organization of inclined plane companies, and authorizing them to construct, operate and maintain an inclined plane railroad for the conveyance of passengers and freight, or either, with such offices, depots, and other buildings as they may deem necessary; also, to establish and maintain a park or pleasure grounds, and for such purposes to hold real estate. Section 10 of this act, provided that whenever the part of the roadway of such railroad operated by steam power shall cross a public highway, such part of the railroad's highway shall pass either over or under such street or highway, and shall be constructed in such a manner and at such a distance above or below such street or highways as not to obstruct the ordinary uses of such street or highway.

March 30, 1877, the legislature passed a law providing that any inclined plane railway company organized under the General Corporation Act of May, 1852, should have "the power to hold, lease, or purchase and maintain and operate such portion of any street railroad leading to or connected with the inclined plane as may be necessary for the convenient dispatch of its business, upon the same terms and conditions on which it holds, maintains, and operates its inclined plane; provided, that no other motive power than animals shall be used on the public highways occupied by such street railway company without the consent of the Board of Public Works in any city having such a board, and the Common Council, or the public authority or company having charge, or owning any other highway in which such street railroad may be laid; and, provided, that no inclined plane railway or railroad company shall construct any track or tracks in any street or highway without first obtaining the written consent of a majority of the abutting property holders."

June 19, 1877, George A. Smith, Jas. M. Doherty and Jos. S. Hill leased the Mt. Auburn Railroad perpetually to the Cincinnati Inclined Plane Railway Company. On Sept. 24, 1885, the Board of Public Works passed a resolution consenting to the use by the defendant either of electricity, cable or compressed air as a motive power "upon the highways in which the street railroads connected with its inclined plane, and held and operated by it are laid," on condition that defendant gave bond in $25,000 to hold the city harmless from any damages to persons or property arising out of the use of such motive power. On Oct. 24, 1888, the Board of Public Affairs gave the defendant permission to erect along the entire length of its road the poles, wires and appliances necessary to operate and maintain its entire line from Fifth and Walnut streets to the Zoological Garden as an electric road, in accordance with plans and specifications submitted to the board. The poles and wires were erected under the supervision of the engineer of the board. On Feb. 23 the stockholders of defendant extended its terminus to Glendale, Hamilton County, Ohio, and certified the same to the Secretary of State under section 3306 of the General Railroad Chapter. And under such extension are now constructing a line of road along the Carthage pike under the consent of the County Commissioners, given March 23, 1889, to use and occupy said pike with double tracks and with necessary appendages and appurtenances of an overhead electric street railroad system. This consent contains the provision that the County Commissioners are to cause the removal of any or all telegraph or telephone poles which may interfere with the operations of said electric road. The grant thus given was modified in September, 1889, but only with respect to the part of the street to be occupied.

Plaintiff's counsel maintain that on this record of the title of defendant the present operation of this road is unlawful for several reasons.

First. That the act of 1876, providing for the incorporation of inclined plane railways, requires that in passing over streets it should be conducted on bridges or in tunnels, and the act of May, 1877, provides that the operation of the railways to be leased shall be subject to the conditions upon which its inclined plane is operated.

Second. That the road connected with the inclined plane to be leased and operated by it under the act of 1877, was to be a "portion" of some other road, and that here the defendant is operating the entire road, nor is it shown that the road as used is necessary to the convenient dispatch of the business of the inclined plane.

Third. That a proper construction of the first proviso of the act of 1877 requires that the consent necessary to permit the use of animal power shall be given by the Board of Public Works and the Common Council of the city.

As to the first reason, it should be said that it is doubtful whether the section referred to in the act of 1876 applies to defendant, for it does not appear that defendant ever accepted the provisions of that act as therein provided. Conceding, however, that the provision is of such a general character as to apply to any company running an inclined plane under whatever law organized, the restriction obviously applies only to places where the inclined plane itself crosses the streets, and not at all to what may be called surface street railroads which the Inclined Plane Company is given power to lease and operate as street railroads are usually operated. The conditions upon which the inclined plane is operated, and to which the operation of street railways by the Inclined Plane Company is to be subject, must, of course, be such conditions as are applicable to street railroads, of which the condition insisted on is obviously not one. Nor has the second reason, in my opinion, any weight. The original Mt. Auburn Railroad Company ran up Liberty, Price, Josephine and Saunders streets. This portion of the road is not used now, but, being taken away, it leaves the part of Liberty to Fifth a portion, and that from Mason to the north corporation line a portion. As to the objection that such roads are not necessary to the dispatch of the business of the inclined plane, I think it may be presumed that they are. It is common knowledge that the great difficulty to be overcome in reaching the plateaus about the city was in climbing the hills, and that the instrumentality by which that was accomplished became the principal feature of any such plan. The approach to the bottom and the departure from the top were incidental, and were certainly necessary to get passengers to the place of ascent and descent.

In so far as the third reason depends on the restriction in the grants to the Mt. Auburn Railway to the use of horse and mule power, it is quite clear that subsequent legislative action enlarging the right of the lessee in this respect has been had, and no reason is apparent why it is not valid.

The chief argument is based on a construction of the proviso, "provided that no other motive power than animals shall be used on the public highways occupied by such street railway company without the consent of the Board of Public Works in any city having such a board, and the common council, or the public authority or company having charge, or owning any other highway in which such street railroad may be laid." Counsel for plaintiff argues that the body usually invested with the power of granting franchises for a municipal corporation is the common council, and that it is not to be presumed that, in this case, the legislature intended to confer final power of that kind on the Board of Public Works, which is a body for the initiation of measures, not for their final legal sanction. Therefore, it is said, the word "and" before "common council" unites these two words with Board of Public Works, and the disjunctive "or" is the dividing word of the clauses, so that by a proper transposition it might be made to read "without the consent of the common council and of the Board of Public Works in any city having such a board, or of the public authority or company having charge, or owning, etc." This construction might be supported but for the use of the word "other" in the second clause. The clause is rather obscurely drawn, but the expression "any *other* highway in which such street railroad may be laid" means any highway additional to those already mentioned in which the same street railroad has been laid. The law is defining the consents required for one railroad passing through several jurisdictions. Therefore we have the conjunctive *and* before common council to indicate that where a railroad has its beginnings in the highways of a city having a Board of Public Works, and extends on to another highway beyond the city jurisdiction, it must have the consent of the common council or the public authority or company having charge, or owning such other highway in which such street railroad may be laid. The bill was evidently passed by the legislature with this city in their minds, for this is the only city in the State where an inclined plane would be necessary, and for this reason the peculiar phraseology is used. It would apply by virtue of the last clause after "*and*" to any other city, but as bearing on the effect of

and, the probable and possible application of the law may be considered.

While it is true that to the common council is usually given the right to grant franchises, it is certainly within the legislative power to give it to the Board of Public Works or Affairs, and of late years there have been many instances where other powers, like those of passing ordinances to assess, and to make certain improvements, have been transferred from council to the Board of Public Works. Moreover, if, by this law, the legislature intended to make the consent of the Board of Public Works and council necessary, it was wholly superfluous to have mentioned the board at all, because, under section 2227 Rev. Stat., the common council could not grant such consent except upon the approval of the board. Some point is made of the presence of a comma after the words "common council" in the certified copy of the bill obtained from the Secretary of State's office, which does not appear in the printed law. I cannot see that this materially affects the construction given above, for the certified copy shows the comma between board and the following *and* just as the printed law does, and that is the point where the question of a separation is important in construing the proviso.

On the whole, then, I am of opinion that the legislature conferred the right upon defendant to use any other motive power than animals, whenever the Board of Public Works should consent. Now, the board did consent, on Oct. 24, 1885, that defendant should use either a cable, compressed air, or electricity. It has chosen electricity, and has procured the necessary authority to erect its poles and string its wires.

Such being the condition of the franchises which the plaintiff and defendant are lawfully entitled to enjoy, considered each without reference to the other, it becomes necessary to inquire first whether any loss has been inflicted upon plaintiff by defendant, and if so, how it has occurred; second, whether such loss, if any, is justified by defendant's franchise, so as to be *damnum absque injuria*, which involves the preliminary question whether the legislature, after having given the plaintiff the right to construct its telephone system, on the faith of which right it has expended large amounts, can confer a franchise on another, the exercise of which will seriously impair the plaintiff's franchise as heretofore enjoyed.

First, a current of electricity cannot be produced without a circuit, that is, unless the negative and positive poles of the generating battery or instrument are connected by a continuous substance, capable of conducting the current. Such a substance may be a metal wire, or if both poles of the battery be connected with the earth by metal wires, the current will find a circuit through the wires and the earth. The earth, by reason of its immense mass, makes an excellent conductor. By what paths the current discharged into it over the wire from one pole finds its way throughout to the wire from the other pole is not capable of determination.

The telephone is a mechanism by which the sound of human speech is reproduced over long distances. Without attempting to describe the exact mode in which this result is brought about, I may say that the sound waves of the human voice produce vibrations in a thin ferrotype plate, which, by means of a magnet and an induction coil, are converted into corresponding variations in an electric current on the connecting wire, and these variations are, in turn, by means of the inducing coil and magnet at the other end, converted into exactly corresponding vibrations on a plate there, reproducing the sound waves of the voice of the speaker in such a manner as to enable the receiver to understand. The current on the connecting wire is a slight one, and the circuit is completed, not by a return wire, but by a ground wire brought into contact with the earth. This contact is usually made by attaching the wire from the negative pole of the single cell battery in each telephone, to a gas pipe or water pipe running down into the earth.

In the Sprague system of electric railways, which is the kind used by the defendant, the electricity used to operate the motors under the cars is conveyed to them by a single overhead wire suspended over the middle of the track, along the underside of which runs a trolley wheel on a single mast attached to the car, making electric connection between the overhead wire and the motor of the car, and allowing the current to pass down through the motor, and onto the track, whence some of it returns directly to the dynamo generator at the power house. A large part of the electricity leaves the track, however, and, by other and various paths, also finds its way through the earth back to the dynamo. In addition to the overhead trolley wire, which is supported by guide wires from iron posts erected on the curb at regular intervals, there is what is called a feed wire strung along on these posts for the purpose of keeping up the required quantity of electricity on the trolley wires. On the streets where are telephone wires, and electric railway wires, their general course must be parallel. The evidence in the case establishes beyond a doubt that, since the defendant began the operation of its line by electricity, in June, 1889, down to the time of trial, the usefulness of all the telephones along the line of the railway have been more or less impaired; that, in many cases, the buzzing noise, which seems to be the chief form of the disturbance, has been so loud and continuous that communication over the lines has been impossible. Nor has the disturbance been confined to telephones on the line of the railway. Telephones several miles from the city, whose connecting wires ran parallel for any distance with the railway, were similarly affected, and the buzzing noise, in many of these, seems to have been quite as deafening as in telephones along the line. Altogether, more than two hundred lines have been affected in this way, to a greater or less degree. The cause of the trouble is undoubtedly the operation of the electric railways, and the way by which it is brought about is two-fold. First, the escape of the electric fluid from the rails, which is called earth distribution or leakage, near where the wire from the telephone is connected with the earth, brings upon this earth connection wire of the telephone varying currents of electricity of much greater quantity than that necessary for the telephone current, and produces upon the magnet and inducing coil an effect which results in vibrations of a very different character from those produced by the human voice, and makes a noise like the buzzing of a saw. Second, a similar noise is made by induction. It is a physical fact of much importance in electric mechanism that, where two wires of two circuits are parallel to each other, and there is a current of varying intensity on one of them, this will produce in the other, in the opposite direction, a current of electricity of similar variation. The insulation of the wires has no effect to reduce the current produced in this way. The amount of induction depends upon variation in the current, the distance of the wires from each other, and the length of the parallelism of the wires. The current upon the trolley wire, and the feed wire of the railway, is quite variable in quantity and intensity, owing to the drain upon the store of electricity by the moving and stopping of the car. Nor is the electricity, as generated, exactly uniform in its flow from the dynamo. The result is that, wherever the telephone wire is parallel with the trolley wire and the feed wire, there is induced upon the telephone wire a current whose variations correspond with the variations of the electrical current on the electric railway wires, and this, acting upon the inducing coil and magnet, produces vibrations of the tin plate, which makes the buzzing sound. It is not possible, in listening to the sounds produced by the electric railway, to say whether it is the result of induction or earth leakage. Some of plaintiff's subscribers, notably Procter & Gamble, have loud buzzing sounds upon their telephones, the ground wires of which are at such a distance from the railway track as to make it quite unlikely that the disturbance could have been caused by earth leakage, while, on the other hand, their wires are for some distance parallel with the trolley and feed wire of the railway company. Other telephones are disturbed on the line of the road, though their wires are not parallel with the trolley wire. Expert evidence attributed the disturbance about one-half to induction, and one-half to conduction or earth leakage. This, of course, is only a rough estimate, and the fact may vary much in particular instances. The injury to plaintiff's service is produced then, speaking in a general way, one-half by the defendant's pouring electricity into the earth, which finds its way into the property of plaintiff's subscribers, and thence into the wire of the telephone, and one-half by a creation of a current on plaintiff's wires in the street by the parallelism of defendant's wire and the varying character of the current. The result has been a very substantial interference with the plaintiff's business, and, if the present condition continues, it will end in a serious loss.

Is it a loss for which defendant is liable? The contention on behalf of the defendant is, that because it has full power to operate by electricity under the law, the loss resulting to the plaintiff is *damnum absque injuria*, and if the plaintiff wishes to avoid the loss, it must adopt safeguards in the shape of a metallic circuit to avoid the difficulty. To this plaintiff replies, that by virtue of its grants, it acquired, before the defendant had a right to use electricity as a motive power, a vested interest in the telephone system as it now operates it, with a grounded circuit, and that not even the legislature of the State could take away from it or injure this franchise, on the faith of which it has expended so much capital and labor.

I am inclined to think that, under the constitutional provision that all laws for the forming of corporations may be altered or repealed (sec. 2, Art. XIII.) it would be in the power of the legislature to grant a right to other corporations for a public use to so use the street as to require the plaintiff company, if it wished to continue in the telephone business, to change its system, and that without any right of action against such corporations. The case of Ry. Co. v. Ry. Co., 30 Ohio St., 604, shows that, where one railway company condemned a right of way across the track of another, that other can not recover for an injury to its franchise as a railroad, or for the increased expense entailed upon it in obeying laws of the State with reference to railroad crossings. However this may be, I am very clear that no intention on the part of the legislature to abridge the granted rights of one corporation by a new grant to another will be recognized by the courts unless such intention plainly appears in the law. In England the power of Parliament is unlimited, and it may even confiscate private property, and *a fortiori* may abridge and destroy chartered rights and franchises. Nevertheless, we find in that country, that where one corporation is granted a right which may be so exercised as to injure or interfere with a right previously granted to another, the presumption of law is that Parliament intended only such uses as was consistent with the rights of the first corporation. In Gas Light and Coke Co. v. Vestry, 15 Q. B. D. 1, plaintiff was a gas company which had laid its gas pipes by virtue of a public grant under a street which the defendant, a public corporation, was charged with keeping in repair, and upon which it used such heavy rollers as to injure the pipes of the plaintiff. The rolls used were economical and well fitted for the purpose, but it was held that, unless the defendants were expressly authorized by statute to use rollers of the size and weight of those which did the injury, the defendant could not justify under a duty to keep in repair which might be discharged by rollers of less weight and without breaking the pipes. Says Findley, L. J.: "The authorities . . . show that an action lies for injury to property unless such injury is expressly authorized by statute, or is, physically speaking, the necessary consequence of what is authorized. If in this case the defendants were expressly authorized by statute to use steam rollers of such a weight as necessarily to injure the plaintiffs' pipes, the plaintiffs would have no ground of complaint. The case would then be one of *damnum absque injuria*. The same consequence would follow if the defendants were expressly authorized by statute to repair in some way which necessarily required the use of heavy steam rollers or other machinery, which could not be worked without injuring the plaintiffs' pipes. There again, although such rollers or machinery were not expressly mentioned, their use would be authorized by necessary implication, and the plaintiffs would be without redress. But unless some statutory enactment can be shown to authorize the defendants to injure the plaintiffs' pipes, the plaintiffs are entitled to redress." This case is peculiarly applicable to the case at bar, because here was a case of a public grant to the gas company enjoyed in a certain way, followed by a grant to the defendant to exercise another right, which if exercised in one way would injure plaintiff's enjoyment of its right, and which if exercised in another would not. The same principle is here applied that courts recognize wherever private property is injured by the exercise of authority granted by the Parliament. See Hammersmith, etc., Ry. Co. v. Brand, L. R. 4 H. L., 171. Queen v. Bradford Navigation Co., 6 B. & S., 631. Geddis v. Proprietors of Bann Reservoir, 3 App. Cases, 430. Att'y Gen'l v. Colney Hatch Lunatic Asylum, L. 4 Ch. App., 416. Att'y Gen'l v. Gas Light & Coke Co., 7 Ch. D., 217. Managers Metrop. Asylum District v. Hill, 6 App. Cases, 193.

Even then, if franchises to occupy the public streets conferred by the legislature may be subject to modifications of their use and enjoyment by other public grants of the legislature, it is certain that unless the legislative intent to make such modification clearly appears, either by express words or by necessary implication arising from the impossibility of enjoying the second grant without such modification, it will not be inferred.

But it is said that this principle can have no place here because the right to occupy the street for the purpose of travel is a superior right to that of using it for the telephone poles. Defendant's counsel, to establish this, rely on the Spring Grove Ave. v. Cumminsville, 14 Ohio St.; Smith v. Tel. Co., 2 C. C. R. 259; Mt. Adams & E. P. R. Co. v. Winslow, 3 C. C. R. 425; R. R. Co. v. Williams, 35 Ohio St. 171; Pike's Ex'rs v. Western U. Tel. Co., decided by this court.

These cases have no bearing upon this case at all, as it seems to me. They involved a discussion of whether the erection of certain structures in the street could be considered a new burden and use, not included in the easement, which the abutting property holder had originally granted to the public, and whether, therefore, he was entitled to compensation. It is unquestionably within the power of the legislature, so far as the public is concerned, to enlarge the benefit to be derived from the streets, so as to include other public purposes than those of mere travel. Ry. Co. v. Lawrence, 38 Ohio St. 45. If this takes more from the abutting property holder than he originally gave, then he may have compensation, but the public cannot complain, for their representative, the legislature, has spoken and granted the use. When the telephone company is granted the right to use the streets, its right is as well founded as that of a street railway company, and in the absence of express legislative direction to the contrary, there is to be no yielding to any other. The provision that the telephone and telegraph lines shall not incommode the public in the use of the street, in section 3461, does not help the defendant. The inconvenience must be determined when the enjoyment of the franchise is entered upon. After rights have been acquired by the outlay of capital and user, there must be express legislative sanction, at least, to warrant a court in finding a use of the street to be an interference with public travel, which was not so when it began. It should be noted in this connection, too, that the plaintiff performs a very important *quasi* public duty, and is in fact a common carrier of messages. It is given the power of condemnation on that ground alone. Pierce v. Drew, 136 Mass. 75; Hockett v. State, 105 Ind. 250.

Coming now to apply the principle just under discussion to the case at bar, what do we find? For ten years, the plaintiff has exercised the franchise of occupying the streets along defendant's lines with its poles and wires, conducting a telephone business with a single wire circuit and an earth return. This mode of return was universally employed when it began, and is to-day in general use. It has constructed a valuable plant, many parts of which will have to be changed at great expense if it is to adopt the only system which will obviate the difficulty it now encounters from the operation of defendant's railway. I refer to the metallic circuit. It is admitted by every one that if the telephone company were to make every one of its lines a complete metallic circuit, with the return wire parallel with the outgoing wire, the disturbance both from induction and earth leakage would be completely removed. It is obvious that if the circuit never came into contact with the earth, the electricity dumped into the ground by defendant could not reach the telephone wire, and so no disturbance could arise there. And it is also a well ascertained fact that if the two wires of the circuit, the outgoing and the return, are parallel and the same length, no effect will be perceptible from induction by a third parallel wire of another circuit, however variable may be the current on that wire. This is because the induction, which actually takes place upon each of the wires of the circuit, results in currents of equal intensity and variability in opposite directions, which, being on the same circuit, exactly neutralize each other. To construct such a circuit for every subscriber, would entail an expense upon plaintiffs, perhaps, even greater than the original outlay. Nor does it seem practicable to have metallic circuit in disturbed districts and allow the other lines to remain s grounded because of the difficulty in arranging the switch boards at the exchange by which subscribers are connected with each other, and for the further reason that in order to connect a metallic circuit with a grounded circuit, the return wire of the metallic circuit must be grounded at the exchanges. The result is that the circuit then made between the two subscribers is a grounded circuit with a long leg and a short leg of wire parallel in the disturbed district. The difference in the length of the two wires prevents the neutralizing effect of the induced current in one wire upon the opposite induced current in the other; because, by reason of the different lengths, that part of the induced currents said to be produced by static induction is unequal. Moreover, to put up metallic circuits through the disturbed districts, and to make the necessary alterations in the switch board, would entail an expense, not nearly so heavy, of course, as a complete conversion into a metallic circuit, but which would be quite substantial. There remains to consider what is called the McCluer device, which consists in a large wire carried into the disturbed district, with which are connected all the return wires of the telephones. This main wire is grounded at a point away from danger of earth leakage. It is likely that such a device would get rid of earth leakage, but it would have no practical preventive effect upon the disturbances by induction, which, as I have said, make up about half of the troubles. The expense of such a device would not be large, still it would be something. It follows, from what has been said, that if the defendant is permitted to use its present single trolley system, it will require the plaintiff either to lose the business of many subscribers, or it will have to go to an enormous expense to obviate all difficulty, or to a less expense to get partial relief.

The plaintiff invested large capital on the faith of its present mode of enjoyment of its franchise. It has continued in such enjoyment for some ten years. To change involves loss and expense. Clearly, then, it cannot be deprived of what so nearly approximates a vested right without clear legislative intent. The defendant cannot be the instrument by which such loss is occasioned unless it clearly appears, and upon it is the burden to show, that in no other way can it enjoy the right to use electricity for its cars. Atty. Genl. v. Gas Co., 7 Ch. D. 217. It is true that the resolution of the Board of Public Affairs approved its plan of structure, but as the legislature in allowing the defendant to use electrical propulsion upon consent by such board is not presumed to have intended a use which would injure plaintiff unless no other use is practicable, so it cannot be presumed to have given the board power to consent to such use. Moreover, the consent upon which

defendant relies was the resolution of the Board of Public Works in 1885, which defined no system of electricity.

Is it impossible, then, for the defendant to run an electric railway along its streets without making these disturbances? It is practically conceded, although there was some slight evidence to the contrary, that if instead of a single trolley wire and an earth return, two trolley wires were used, one for the positive and the other the negative current, the difficulties would be just as completely obviated as if the telephone company used a metallic circuit. There is such a system in use in a number of cities of the country. There are two in operation in this city, and two or three more are projected here. In such a system the electricity is carried from one wire down through one trolley wheel and mast to the motor of the moving car, and returns from the motor to the other wire by means of a second trolley wheel and mast. It is said it is wholly impracticable.

The single trolley system is in use on nine-tenths of the electric railway systems in the United States. This arises, doubtless, from two facts: First, that it is, perhaps, one-fourth cheaper in its outside construction; and, second, because in single track railways, of which there are many more than double track, where is is necessary to have many switches and turn outs, the complications of wires overhead increase much more rapidly with a double trolley than a single trolley. But in the case at bar we have a double track from one end of the road to the other, so that no switches are required. Mr. Short, who is a skilled mechanician, engaged in a company which bears his name, and which erects both the single and the double trolley systems, says that he recommends the single trolley for single tracks and the double trolley for double tracks. He seems the only witness on either side that is free from suspicion of bias.

It is admitted by many of defendant's witnesses, that electrically the double trolley system is exactly as good as the single trolley, and this must be so, because a return by wire makes quite as good a current as by the earth. The claim that electricity in the wheels passing to the track gives additional traction is conjectural, and is not apparent in a practical comparison of the grades ascended by the cars on the two systems. The objection to the double trolley system is the mechanical difficulty in making proper switches and in supporting the superstructure. In the double-track road like the defendant's the first difficulty does not arise, and the second difficulty has in fact been overcome in every double trolley system which has been erected. On the whole, then, it seems to me that there is no serious obstacle to defendant's using the double trolley. A change will no doubt involve the defendant in substantial expenditures in the overhead structure, which will have to be made heavier. But nearly all of the material can be used again, and no material changes need be made, either in the dynamos, engines, or motors.

The defendant can not rely on an estoppel. It was notified by the plaintiff as early as March 12, 1889, some three months or more before its electrical plant was put into position, that the use of the single trolley system would interfere with and injure the use of the plaintiff's telephone lines. Defendant promised plaintiff that the system was an improved one, which would give rise to no trouble. In so doing, it relied on the assurance of its vendor, the Sprague Company, and the peril of the fulfilment of such assurances must lie with it.

But it is said that the injuries here occasioned are not cognizable in the courts, even if the telephone company is to be regarded as a private property owner in the enjoyment of the telephone franchise, and the case of Frazier v. Siebern, 16 Ohio St. 614, is relied on in this connection. That was a case between adjoining proprietors, where the defendant dug a well on his premises and knowingly diverted percolating waters which made a spring on the plaintiff's premises, and dried the spring. This was held to be *damnum absque injuria*. There is no parallel between that case and the one before us. There the spring owner had no ownership in the percolating waters until they appeared on his property, and the injury he suffered arose simply from his neighbor making his own that to which, while it was on his premises, he was lawfully entitled. In the case at bar, the disturbances, in their two-fold origin, present slightly different circumstances, but call for the application of the same principle. The earth leakage arises from the defendant's pouring electricity into the earth, which, following a course as natural for it as the seeking of a lower level is for water, comes upon the premises of plaintiff's subscribers, and by getting upon the wires of the telephone, does harm. The plaintiff, by contract with its subscribers, has a right to have its wire where it is, and, for the purposes of this discussion, has exactly the same right to object to the presence of electricity on his premises caused by defendant and resulting in damage, as would the subscriber himself. It is impossible to distinguish such an injury in principle from the case of one discharging filthy waters into the ground so that it shall percolate into another's premises and there do damage, or of one's causing smoke and cinders to be constantly thrown into one's windows and injuring one's enjoyment of one's property. These are all examples of nuisances which have been held to give a right of redress. Ballard v. Tomlinson, 29 Ch. D., 115. Ry. Co. v. Gardiner, 45 Ohio St., 309.

In Reinhardt v. Mentasti, 42 Ch. D., 685, it was held to be a nuisance for the defendant, a pastry cook, to put in a a room in his house, which adjoined a room of the plaintiff long used as a wine cellar, a stove so large that, when it was being used, it heated the wine cellar and made it useless for that purpose.

In Attorney-General v. Gas Co., 7 Ch. D., 217, the creation of noisome gases was held a nuisance. How can injury from electricity be distinguished from an injury by water, gas, smoke or heat. The term nuisance signifies anything that causes hurt, inconvenience, annoyance or damages. Columbus Gas Co. v. Freeland, 12 Ohio St., 392.

As was said in Reinhardt v. Mentasti, 42 Ch. D. 685, "the principle governing the jurisdiction of the court in cases of nuisance does not depend on the question whether the defendent is using his own, reasonably or otherwise. The question is, does he injure his neighbors?"

The disturbance by induction is of similar character, except that the force is applied from one wire to the other through the air instead of the earth. If, as we have found, defendant is not entitled to interfere with plaintiff's enjoyment of the telephone franchise, here is a direct act of interference. I presume that, if one man arranges a set of mirrors, with reference to the sun, so as to concentrate its rays upon his neighbor's property, and so burns and damages that property, no question would be made of his liability. What difference can there be between such a case and the inducing of a damaging current on plaintiff's wires. The way in which the force acts may not be as well understood in the case of the mirrors and the rays as in that of electric induction, but the fact of the cause and the result is quite as clear. The contention by the defendant that the plaintiff, in resisting injury which reaches it through the medium of the earth and the air, where the defendent is the known moving cause of such injury, is making a claim to the exclusive use of the earth, is misleading, until it is examined, when it becomes apparent that the same claim might be made as to percolating waters, as to heat, as to smoke, and as to odors. The fact is, nuisances are generally injuries arising from a cause which is not in contact with the property injured, and which must have come through the medium of the earth or the air, or the waters under the earth.

Then it is said no claim can arise for disturbances by the defendant, because there are similar disturbances from other causes, for which the defendant is not responsible, and Wood v. Sutcliff, 2 Simons N. S. 163, is cited upon this point. That was a case where the injury sought to be enjoined was the pollution of a stream from which plaintiff had, in time past, drawn water for his business. One of the reasons given by the vice-chancellor for refusing the injunction was that others than the defendant were polluting the stream. The real basis of the decision was the laches of the defendant in asserting his right, for he had provided a new supply of water, and had not used the river for some time. This case presented no difficulty in considering the case at bar, first, because there are no substantial disturbances shown, other than those caused by defendant, and, second, because the case itself is not sound authority.

See Crump v. Lambert, 3 Eq. Cas. 414; Crosky v. Lightowler, 2 Ch. 478; Walter v. Selfe, 4 De Gex & S. 315.

In the last case, the court said that, because one man was maintaining a nuisance against the plaintiff, was no reason why defendant should set up an additional nuisance.

We find, then, that defendant is inflicting a legal injury upon the plaintiff in the nature of a nuisance from which has already arisen loss, and which must inevitably cause loss in the future, constantly recurring. It is said that the damage is not irreparable, because the plaintiff can expend money and avoid it, and, in the same way can arrive at its exact loss, and that, therefore, its remedy is not by injunction, but at law. Neither of these claims can be sustained. The most frequent exercise by a court of equity of the power of injunction, is to prevent the continual recurrence of injuries from nuisance. The ground is that the plaintiff should not be put to a multiplicity of suits and endless litigation. To say that in order to entitle a man to obtain an injunction against such an injury, that he should not be able, by the expenditure of even vast amounts, to avoid the injury, is to say that no injunctions can ever issue for such a cause. The point is that he is not obliged to expend money to protect himself when a neighbor injures him, but he may appeal to the courts; and when upon the law side, he finds that the remedy there afforded is inadequate because of the necessity for bringing a separate suit for each injury, he may fairly say that by appeals to legal tribunals, he can not repair his damage, and therefore his loss will be irreparable. As to the ascertainment of damages, it is by no means true that in each suit the entire cost of introducing a metallic circuit or a McCluer device would be the measure of damages for this sort of interference, and the very reason for going into a court of equity is to get into a forum where all the injuries can be considered together.

The authorities are overwhelming that for such injuries as those arising at the bar the proper remedy is by injunction. Imperial Gas Co. vs. Broadbent, 7 H. L. C. 601. Crump v. Lambert, L. R. 3 Eq. Cases, 409. Crawford v. Rambo, 44 Ohio St. 287. Attorney-General v. Cambridge Consumer's Gas Co., 4 Ch. App. 71. Gas Co. v. Vestry, 15 Q. B. D. 1. Cook v. Forbes, L. R. 5 Eq. Cas. 166.

The order of the court will therefore be that the defendant be enjoined perpetually from the use of the system of electric railway propulsion as now operated by them, or any other which will occasion similar disturbances to those now caused by defendant's single trolley system. The order of injunction will not take effect unil six months from this day, with leave to the defendant to apply to the court hereafter for further time, if necessary, in a *bona fide* effort to make the necessary changes. The costs of the action must be paid by the defendant.

Decree accordingly.

Decree.

This cause coming on to be heard upon the pleadings and the evidence, and having been fully argued by counsel and submitted to the court without the intervention of a jury, the court, upon consideration thereof, finds that the plaintiff lawfully maintains telephone lines upon the streets named in the petition, and upon the Carthage turnpike, and has so maintained the same ever since a time long prior to the introduction of electromotive power upon the street railway of defendant, and that said telephone lines are maintained and operated in the manner set forth in the petition: That defendant began the operation of cars by means of electromotive power upon its street railways, on the ——— day of June, 1889, and by reason thereof, and especially of the manner in which the electric current is permitted to pass from the wheels of defendant's cars into the rails, and thence into the earth, great injury has been and continues to be inflicted upon the plaintiff in the manner described in the petition, and that great and irreparable injury will be inflicted upon the plaintiff by the continued operation of defendant's cars in the manner in which they are now operated, and will continue to be operated, unless restrained by order of this court. And that plaintiff has no adequate remedy at law for said injury.

The court further finds that there is a known mode of operating street cars by electromotive power by means of the double trolley, available to the defendant, the use of which will avoid and prevent the injury to the plaintiff above mentioned.

As matter of law, the court concludes that defendant is bound to adopt some mode of propelling its cars other than the one which inflicts the said injury upon the plaintiff, to which finding and decision of the court the defendant excepted at the time the same was made, and moved the court to set the same aside, and grant it a new trial:

First. Because the finding and decision of the court is not sustained by sufficient evidence, but is against the weight of the same.

Second. Because the finding of the decision of the court is contrary to law.

Which said motion the court overruled, to which ruling the defendant at the time the same was made, excepted, and presented to the court its bill of exceptions herein, which, being found by the court to be true, is allowed and signed, and, on motion, is hereby made part of the record of the case; and, thereupon, the court orders, adjudges, and decrees, that the said defendant company be and it is hereby perpetually restrained and enjoined from operating any car or cars upon the street railway track mentioned in the petition, or any of them, or upon any tracks laid or to be laid upon the Carthage turnpike, by means of electric currents passing from a wheel or wheels of such car or cars into the rails of said track or any of them; or by means of electric currents, the whole or any part of which may be knowingly permitted to pass into the earth, or which the earth constitutes any part of the conducting medium in such manner as to cause injury to the plaintiff. To all of which the defendant excepts.

It is further ordered, that the operation of this decree be and it is hereby stayed for the period of six months from date hereof, with liberty, upon the part of the defendant to apply for an extension of said time.

The court further orders, that Alex. H. McGuffey be and he is hereby appointed Master Commissioner herein, with directions to ascertain and report the amount of the damages, in money, heretofore sustained by plaintiff, and hear evidence for that purpose, and report the same to the court, and this cause is continued for the hearing and disposition of said report.

And the court orders, that defendant pays the costs of the action accrued to date; but the court further orders that, in case the damages found by said Master do not exceed the sum of $200, the costs of the reference shall be paid by the plaintiff. To all of which defendant excepts.

STATE OF OHIO, }
HAMILTON COUNTY, } ss.
CITY OF CINCINNATI, }

I, John B. Peaslee, Clerk of the Superior Court of Cincinnati, within and for Hamilton County, do hereby certify that the foregoing is a true and correct copy of an order made by the said court on the 12th day of February, 1890, Min. 564.

Witness my hand and the seal of said court, at Cincinnati, this 14th day of February, A. D. 1890.

[SEAL.] JOHN B. PEASLEE, *Clerk.*
By R. H. BECHT, *Deputy.*

Puck's Girdle Round the Earth.*

BY HERBERT LAWS WEBB.

In taking up such a vast subject as that presented by submarine telegraphy, in its present almost perfected stage, the difficulty is to decide where to begin and where to leave off, and what to put in the middle. Almost any branch of the subject, if treated in detail, might well occupy an entire paper, and we could easily spend a whole evening in discussing the manufacture of cables, and devote another to their submersion, a third to repairing, a fourth to operation and a fifth to testing; and even then we should have by no means exhausted the subject. The early history of submarine cable laying is a fascinating study to the electrician, especially when we consider that it was this branch of telegraphy which gave rise to electrical engineering, and that the solution of the many electrical problems which presented themselves in the early days of the art, greatly increased our knowledge of the laws of electricity.

The statistics belonging to submarine telegraphy to-day also make an imposing array. However, in compiling this paper I have decided to abjure history and statistics, and to omit detailed reference to various other branches of the subject, confining myself to a rapid description of the more important operations connected with the manufacture and laying of a cable.

Before proceeding any further I must express my regret at being unable to show you any drawings of cable machinery or appliances; if I had been able to do so, I am sure that this paper would have gained in interest and its defects would have been less apparent; but such drawings are not easily made from memory, and as cable ships and cable factories do not congregate on this side of the Atlantic, it has not been possible for me to collect any drawings to show you here to-night.

We will now suppose that the contract for laying our cable has been made and signed, and the manufacture is about to commence. I do not propose to stay long in the factory, as I have no doubt you would like to get on board ship as soon as possible, but a glance at the specification may not prove uninteresting. The conductor is to consist of a strand of seven copper wires, weighing 106 pounds per nautical mile, the centre wire to be passed through a compound before stranding the outer wires around it. The dielectric is to consist of at least three coatings of gutta percha; between the conductor and the first coating, and between the successive coatings, which are to adhere perfectly to each other, is applied a layer of Chatterton's compound. The dielectric weighs 140 pounds per mile. These proportions are for cables of moderate length.

When the cable has reached this stage it is called "core." The core is coiled on reels in mile lengths, weighed and tested before being passed for the outer protection to be applied, by the engineer of the purchasing company or government. The electrical conditions required are as follows: The conductor resistance is not to exceed 12 ohms per nautical mile at 75 deg. Fahr. The electrostatic capacity is not to exceed .37 microfarad per nautical mile at the same temperature. The dielectric resistance after one minute's electrification is not to be less than 250 megs. per nautical mile at 75 deg. Fahr.

The outer protection is as follows: The deep-sea type is served with tarred jute, put on wet, and sheathed or armored with 15 No. 13 B. W. G. steel or homogeneous galvanized iron wires. Outside the armoring goes a layer of Russian hemp, impregnated with tar or compound, and finally an envelope of tape soaked in compound, two tapes being put on in reverse directions. This makes a pretty good cable, strong and light. The weight wet in air is 1¾ tons per knot, and the breaking strain 5½ tons, the specific gravity compared with sea water being 2.5.

We next have "a light intermediate" type, armored with 12 No. 9 B. W. G. wires, and weighing 2.9 tons per knot; a "heavy intermediate" type armored with 10 No. 5 B. W. G. wires, and weighing 4.5 tons per knot, and the "shore end" type, armored with 10 No. 0 B. W. G. wires, and weighing 10.5 tons per knot, with a breaking strain of over 15 tons.

For very rocky ground an even heavier type of shore end cable is used with double armoring, the weight per knot being sometimes as much as 20 tons. The completed cable is coiled into large store tanks and tested; in fact, a submarine cable is continually being tested from the time when conductor and dielectric are united so as to become core up to the time of its submersion and

* A paper read before the New York Electrical Society, Wednesday, Feb. 12, 1890.

placing in service. And even then we don't let it alone, but test it periodically once a week or so to see how it is getting along. There is nothing electrical which gets so much testing as a submarine cable, except perhaps the electricians engaged in looking after them.

We now pass to the cable-ship. I will take the "Dacia"; she is not the largest or best known, but she has done a vast amount of service and been in most parts of the world. She has laid cables in the West Indies and the Gulf of Mexico, on the west coast of South America and on the west coast of Africa, in the Mediterranean and among the British Isles. She has been east to the Persian Gulf, and I hope will one day go west to the Northern Pacific. When the Pacific cable is laid, then Puck's girdle will be indeed complete.

The "Dacia" is a screw steamer of 1,856 gross tonnage; 283 feet long, 34.7 beam and 17.9 depth of hold. She has four cable tanks of a joint capacity of 1,500 tons of cable, and five smaller tanks for buoy and grappling rope. The paying out drum has a pair of small horizontal engines of about 20 h. p.; the picking up drum has more powerful engines, of 50 h. p. There are several cable ships of much greater carrying capacity than the "Dacia," notably the "Scotia" (an old Cunarder), the "Faraday" and the "Silvertown," formerly the "Hooper." This vessel, since the "Great Eastern" retired from her scientific career, is the largest cable ship afloat, though only a few tons more than the "Faraday." She cannot be considered a handsome ship, as her length is only about six times her breadth, 350 feet length to 55 feet beam. Her main tank is 53 feet in diameter, just a foot to spare on each side, and 30 feet deep. Her carrying capacity is enormous, both as regards cable and stores and a point of great importance also as regards coal. She can carry in bunkers and forehold more than 2,300 tons of coal, and this gives her powers like those of the orator about whom it was said that "he could jump up higher and stay up longer than any other talker." She can travel further and stay at work longer without coaling, than any other cable steamer afloat. The enormous tanks also add greatly to the facility of coiling cable on board quickly and paying out at great speed. The "Silvertown" laid the greater part of the Central & South America Company's system of cables stretching from Lima, Peru, to Salina Cruz on the coast of Mexico. On this expedition she carried 2,370 knots of cable, weighing 4,881 tons, and the entire length was shipped in 22 days, or at the rate of over 100 knots per day, the greatest length coiled on board in twelve hours being 65 knots, nearly 5½ knots an hour. During the laying of these cables the speed of paying out often reached 9 knots an hour, an unusually high figure, due chiefly to the ease with which coils of such large diameter unwind. The cable steamers are moored out in the river at some little distance from the factory, and the cable is guided on board by leads mounted on barges placed at intervals between the riverside and the ship. The cable is hauled on board by a small engine and coiled away in the tanks by gangs of men, who coat the cable liberally with whitewash to prevent one turn sticking to its neighbor; boards are also placed over each layer or "flake," as it is technically called, with the same object. A "foul turn" or a "foul flake," consisting of several turns of cable coming up together out of the tank during paying out, are very undesirable events, almost sure to result in damage to the cable and possibly in injury to the men, hence they are guarded against by every possible precaution. Loading a cable ship is generally a pretty slow operation; it would undoubtedly be much expedited if the ship were able to get right alongside the factory, but none of the four cable factories on the banks of the Thames has dockside premises. The ships naturally have to lie a long way out in the river, and the mooring ground has to be dredged frequently at great expense, as the draught of a cable ship fully loaded is very great. I have heard it said that the ship which laid the German Union cable, a very heavy type, which connects Emden with Valentia, was on that occasion the deepest laden ship that ever left the Thames, her draught aft being, if I recollect aright, about 31 feet.

We will now assume that the cable is all safely on board and in first-class condition, and the expedition is ready to start. The staff on board now claims our attention. The engineer-in-chief is the principle figure, he having entire charge of the whole expedition. As a general rule, he knows the whole business thoroughly; can navigate the ship, take charge of the paying-out or picking-up gear, localize a fault in the cable from the testing room, fit up a telegraph office, and, if necessary, send or receive the message himself; so that whatever orders he may give he knows all about what he is talking of. Then come the captain and the usual ship's officers and engineers. The cable staff consists of two elements—engineers and electricians. The engineers look after the mechanical part of the work, and the electricians keep a close watch on the electrical conditions of the cable. Besides these, who are all "officers," there are trained jointers, whose special duty is to make the electrical joints in the cable, and a large number of cable hands and foremen, together with the usual crew of firemen and sailors. Thus it will be seen that the ship's company of a cable steamer is a very numerous one, seldom numbering, on a ship of about 2,000 tons, less than 140 officers and men. As a general rule, every ship also carries one or more representatives of the government or company for whom the cable is to be laid. These gentlemen watch all operations, test the cables, check lengths laid, and so on, in the interest of the purchasers, and certify as to the work having been correctly carried out. There is in London a firm of electricians who make a specialty of acting as consulting engineers to telegraph companies buying submarine cables, and their staff check very thoroughly everything done by the contractors, even to taking observations and plotting out on their own charts the course followed by the ship while laying cable.

The first thing to be done before laying a cable is to make a thorough survey of the ground over which the cable is to be laid. In the early days of cable laying, sounding was very imperfectly carried out, but of late years, and especially since the introduction of Sir Wm. Thomson's sounding machine, the practice in this respect has been very greatly improved. In 1860, Mr. Preece, when reading a paper on cables before the Institution of Civil Engineers, urged the absolute necessity of obtaining a clear and definite survey of the bottom on which a cable was to be laid. The president of the evening asked Mr. Preece from his chair in a gruff tone of voice whether he wished the bottom of the sea to be surveyed like the land for a railroad. The reply was: "Certainly, no cable should be laid on the bottom of the ocean until we know what the bottom of that ocean is." And this rule is carried out at the present day as far as possible. Soundings were formerly taken about every one hundred miles or so, and on some occasions at lesser distances apart, and it was taken for granted that the depth in between was the same as that found by the soundings; or, if the two soundings varied much, it was supposed that there existed a gradual slope between the two points, whereas there might have been a submarine mountain or a big valley which had been passed over altogether in sounding, but would prove fatal to the life of a cable laid across them. Apart from the irregularity of the bed of the ocean it often happens that the bottom consists of substances which would have a deleterious effect on the armoring of the cable, so that it is very necessary to obtain samples of the bottom and submit them to analysis. It is the general practice now before laying a new cable to make a very thorough survey of the ground. When the Central and South American cables were laid, the contractors chartered the repairing ship stationed on the West Coast, and sent her up the coast to take soundings over the whole route. The engineer in charge of this ship told me that he always entered in a special book any soundings which appeared to him as indicating peculiar ground.

He found some of these suspicious soundings off a place called Cape Blanco, on the north coast of Peru. Well, a day or two before the whole system of cables, some 3,000 miles was about to be handed over to the telegraph company, the section between Peru and Ecuador broke down. It was the shortest section on the whole line and had been down for about eight months, testing splendidly every day, but it went suddenly, and the break was found off Cape Blanco where the engineer who carried out the repairs, who happened to be the same gentleman that had made the soundings, predicted that it would be found. And I have noticed that the cable has broken at the same spot several times since. In this case, although the soundings indicated the existence of a dangerous place, it was impossible to avoid it without making a long *détour* out to sea, but such spots when found, are generally given a wide berth.

The sounding machine in general use is a modification of that designed by Sir Wm. Thomson, who has done so much in other directions for submarine telegraphy. The machine consists of a small iron drum mounted on bearings and arranged on a bed which allows of its being slid out over the stern of a ship for paying-out, or being drawn inboard and geared to a small engine for picking up. The sounding wire is steel piano-forte wire of No. 20 B. W. G., weighing about 15 lbs. per knot. For preserving the wire from rust when not in use the drums are kept in small tanks containing a weak solution of caustic soda.

There is a variety of sinkers and tubes for bringing up specimens of the bottom, the most popular being the "Sigsbee," designed in 1880 by Capt. Chas. D. Sigsbee, of the U. S. Navy, and used by him in surveying the bottom of the Gulf of Mexico. This instrument consists of a brass tube, 2¼ inches in diameter, and 12 to 14 inches long, which passes through a heavy iron sinker, the sinker being attached to the tube by a wire sling, which is looped over a tumbler working on an axis in the stem. On the weight striking the bottom the tumbler is released automatically, leaving the tube free to be drawn up without the sinker. The tube is fitted with a combination of valves, and secures a specimen of the water from the bottom, and also of the bottom itself. For sounding in shallow water non-detachable sinkers are used, and on special occasions, such as when making a survey of a bank, drags and swabs are employed. We also use capsizing thermometers for registering the temperature of the bottom water, and thermometers are sometimes attached to the sounding line at intervals, in order to obtain observations of the temperature of the water at different depths.

Work with the Thomson sounding machine is very rapid, as compared with the old method of employing a hemp line. The average rate of descent of the sinker is about 100 fathoms per minute, and the same speed is sometimes attained in picking up the tube, but the average rate of picking up is about 70 fathoms per minute. The deepest sounding taken in the Atlantic by the "Dacia," in lat. 23° 29′ N., Lon. 61° 47′ W., registered 3,233 fathoms, or about 3½ statute miles. The sinker was 33 minutes, 50 seconds descending, and it took 45 minutes to heave up the tube, altogether 1 hour 18 minutes and 50 seconds. To make this sounding with a hemp line would have taken about four or five hours.

A very thorough survey was made between Cadiz, Spain, and the Canary Islands, previous to laying the cable between those two points in 1883. Two ships made zigzag courses across the proposed line of the cable, and soundings were taken every few miles, and more frequently if circumstances warranted the delay. In this manner the ground was covered very effectually. On board the "Dacia" we had a very interesting time and made some very remarkable discoveries. To give you an idea of the amount of sounding we did, I may mention that we took nearly three weeks going from Cadiz to the Canaries, instead of three days if we had steamed there at full speed. We came across several banks where deep water was believed to exist. One of these banks nearly escaped us, as we were sounding at long intervals, but a suspicious shoaling was noted on comparing one sounding with the previous one, and as a little further on deeper water was found, we tried back, stopping to sound every few miles. The depth decreased very rapidly and excitement ran high when the sinker finally found bottom at 68 fathoms. We had found a submarine mountain, raising its crest to within a few hundred feet of the surface, rising precipitously from a depth of nearly 2,000 fathoms. Such incidents as this show clearly the necessity for very careful surveys of ocean cable routes. This bank was right on the proposed course of the cable, and, if the cable had been laid as originally intended, would have proved fatal to its existence. We spent three days in surveying the bank and determining its limits, and it is now marked on the Admiralty charts as "Dacia Bank."

The cable steamer "Seine" found a similar bank in the same part of the Atlantic some years previously, but she did not find it by sounding. She was laying a cable from Madeira to Lisbon, and discovered the existence of the bank because she laid the cable right across it. The cable festooned and broke, and something wrong was naturally suspected on board the "Seine." When making the repairs, soundings were taken, and a shoal now known as the Seine Bank, was discovered. One more reference to sounding and I have done with this part of the subject, which, by the way, is a very fascinating one, and might well occupy our attention for a whole evening—in fact, a former shipmate of mine, Mr. Stallibrass, read, a few years ago, before the English Institution of Electrical Engineers, an extremely interesting and elaborate paper on "Deep Sea Sounding in Connection with Submarine Telegraphy." The further reference I have to make to sounding is in illustration of the dangers that may lie hidden in spite of the most careful survey. For the Cadiz-Canaries cable we took several hundred soundings, and it seemed as if the ground had thoroughly covered, yet another bank was struck while the "Dacia" was laying the cable. Fortunately, the engineer in charge of the deck grasped the situation in a moment, and immediately, on observing the altered strain on the cable, he ordered the ship full speed astern, and paid out a lot of slack. These prompt measures saved the cable from breaking, and it has worked now for six years without an interruption, but this bank is looked upon as a weak link in the chain.

The preliminary survey having all been made and suitable spots selected for the landing places, the first operation connected with the actual laying of the cable is reached. This is landing the shore end. The entire operation is generally conducted from the ship in the following manner: The ship anchors opposite the landing place as near in shore as she can safely get. Two large spider sheaves, or pulleys, are moored firmly on the beach a hundred yards or so apart, and a five-inch manilla rope is run out from the stern of the ship, passed round the two spider-sheaves, brought back to the bows, and taken to the picking-up gear. The end of the cable is bent on the rope, and the picking-up gear being set in motion the cable is gradually hauled on shore. The strain on the rope is lessened by the paying-out gear being also moved by steam, which eases the heavy shore-end out of the ship. As the cable leaves the stern, large balloon buoys are lashed to it at intervals of a few yards, thus the cable is floated all the way from the ship to the shore. In this way there is no risk of injuring it by dragging it over rocks, and a straight line is preserved. This method is much superior to that of landing a shore end from boats or barges, as then there is no danger of introducing kinks, the work is much slower and more cable is used. In the manner I have described the whole operation can be carried out in a few hours, and there is the additional advantage that the engineer in charge of the work has it all under his own eye—he has no difficulty in making both ends meet, because he has both ends right there. A novel explanation of the purpose of the balloon buoys was once given by a French gentleman, who, with others, was watching the landing of a shore-end at Marseilles. One of the lookers-on inquired why the buoys were required on the part of the rope traveling from the ship to the shore and not on the part going from the shore to the ship. The French *savant* explained that they were used to float the cable ashore so as to keep it dry!

Sometimes it is not convenient or practicable to carry the hauling line back to the ship and heave in from on board. On several occasions in Peru and Chili, where the landing places happened to be in proximity to the railroad track, the line was made fast to a locomotive and the cable was hauled on shore very speedily and easily. Once, in the Canary Islands, where a very rocky and awkward beach was encountered, a team of oxen was engaged, and they made pretty short work of landing our shore end.

A small iron cable hut is put up on the beach, at a safe distance from the water, for the reception of the cable ends, placing the testing instruments and making the connections between the main cable and the underground lines leading to the town where the office is situated. These huts are carried in sections on board the ship and can be put up very rapidly. A deep trench is dug from low water mark to the hut and the cable is securely buried. As soon as the shore party signal "Enough cable on shore," paying-out is stopped, the hauling line is detached from the cable and drawn on board, the spider-sheaves and other tools are taken back to the ship, boats are dispatched to cut the lashings of the buoys and tow them back, and all is made ready on board for paying-out.

The first shore end is generally laid a few miles out to sea and the cable cut and buoyed. The ship then makes for the other terminus of the line, lands the shore end there, and starts paying out towards the buoy on the first end. We will suppose this to be the *modus operandi*. All being clear, orders are given to weigh anchor, the ship's head is pointed out to sea and paying out commences. The cable comes out of the tank around a "fairlead," which guides it into a trough provided with iron rollers, from the other end of which it passes over a pulley on to the paying-out drum, from the top of the paying-out drum the cable dips under the dynamometer, goes up over a fixed pulley and over the stern sheave into the sea. The paying-out drum is about six feet in diameter, and is provided with a powerful strap brake bearing on the shaft by which strain is kept on the cable to prevent it running out too fast. The cable takes six turns around the drum so that there is no chance of its slipping. A strophometer is fitted to the drum, and indicates immediately any variation in the rate of paying out, and a counter registers the number of revolutions so that the length of cable paid out can be ascertained at any time. The dynamometer consists of a heavy iron sheave mounted on a carriage which slides up and down a vertical iron framework as the strain on the cable varies. The dynamometer carriage carries a pointer which passes in front of a scale indicating thereon the strain on the cable. This scale is four-sided, each side being calibrated to indicate the strain on the cable in hundred-weights, according to the weights placed on the dynamometer carriage. The picking-up gear is similar to the paying-out, except that it is of much heavier construction and moved by more powerful engines.

To get back to our work, we find the paying out going on steadily, the cable making the machinery hum, and spattering everybody about liberally with whitewash as it flies over the different pulleys. When a few miles have been paid out the ship is slowed down and finally stopped, and preparations are made to cut and buoy the cable. The buoy, a huge iron affair surmounted by a flagstaff, is ready lashed outside the rigging; one end of a stout iron chain is made fast to the buoy, the other terminating in a couple of mushroom anchors, which constitute the buoy moorings. The chain is "flaked" or coiled up in a box on the deck, the two ends leading out of a hawse-pipe to the buoy and anchors quite clear of anything on deck. The ship being hove to, the cable is made fast at the stern sheave by means of stoppers; it is then cut and the end of the core carefully sealed up by the jointer. The end of the cable is then securely made fast to the buoy moorings, and at the word "let go" the stoppers are loosed, the mushroom anchors dropped overboard, the chain rattles out through the hawse-pipe, and a moment later the buoy is cut adrift and drops over with a grand splash.

The first shore end is now laid and buoyed, and the ship immediately sets on for the other terminus of the line. Arrived there, the hut is landed and set up, a complete set of testing instruments installed, and a couple of electricians told off from the ship's electrical staff to take turn and turn about in "spot-watching" all the time the ship is paying out the main cable. The shore-end is landed in the same manner as previously described, and the ship starts paying out first shore-end, then, as the water deepens, heavy intermediate, then light intermediate, and, finally, when the 200-fathom line is passed, the deep sea cable continuity test is kept on the cable and signals are exchanged between ship and shore during the whole time of paying out.

The cable is charged on board ship with a battery of 100 cells, a marine reflecting galvanometer being kept in circuit. At the cable hut on shore, the cable terminates at one pillar of a discharging key, the end thus being insulated, so that the insulation resistance of the cable is always under observation on board the ship. It is curious to notice how the insulation steadily rises as more and more of the cable is exposed to the low temperature and tremendous depths of the ocean. Every five minutes the "spot-watcher" on shore depresses the lever of his discharging key, thereby discharging the cable through his galvanometer into a condenser; he notes the deflection and the man on watch in the testing room on board ship does the same; at the end of every hour the battery on board is reversed. If the ship desires to call the attention of the shore so as to join up for speaking, he reverses before time, or keeps the same pole on beyond the hour. If the hut wishes to speak the ship, he discharges at shorter intervals than those prescribed. For speaking, if the cable is a short one, a double current Morse instrument is used, if the cable is a long one the mirror has to be employed. This continuity test is a very simple and a very effective one, as long as the man on watch in the hut doesn't go to sleep, and he very seldom does.

The responsibility of giving those signals every five minutes weighs heavily on one's conscience and keeps him awake. If a fault passes overboard—it sometimes happens that a slight defect is opened up when strain is put on the cable—it is noticed almost at once. I remember discovering such a fault on one occasion almost immediately after it left the ship's stern, by the reduced deflection on making the discharge. We notified the ship at once, and after

tests had been made from on board to localize the fault, paying-out was suspended and the cable was picked up until the fault was brought on board. The fault was then cut out, the cable spliced on to that in the tank, and paying-out was resumed. Such an incident as this emphasizes the value of a careful continuity test. They kept quiet on board then, but took it out of us afterward by blowing us up for being late in answering a call.

A somewhat ludicrous event happened during the laying of the C. & S. A. cables which I may relate here, while speaking of continuity tests. The final section was being laid, and as the electrical staff has been much reduced in numbers owing to the necessity of leaving two men at each hut, the secretary of the expedition was pressed into service to do a little spot-watching in the ship's testing-room. Paying-out was being carried on at a pretty high speed and a slight accident happened in the tank, a couple of turns came up together, fouling a lantern at the side of the tank but doing no damage, as the turns freed before reaching the machinery, and it was hoped that no harm had been done to the cable. The newly recruited electrician, who felt the responsibility of his position very keenly, was particularly cautioned by the engineer in charge to keep a very careful watch and to advise him without a moment's delay if he noticed the least unsteadiness in the spot, as it was feared that the slight accident might have resulted in a fault. All went well for a short time. Suddenly the secretary came rushing out on deck with the information that the spot was off the scale. The ship was promptly put full speed astern, paying out was stopped and the cable was made fast, and all hands repaired to the testing-room, where it was found that the galvanometer lamp had gone out! When it was refilled the spot reappeared in its proper place. After that little experience my friend was careful to see that his lamp was properly trimmed.

Once in deep water, everything runs as smoothly as clock-work. Mile after mile of cable comes up from the tank, glides along the trough and over the pulleys, whirls round the drum, dips under the dynamometer and bobs up over the stern sheave to trail away into the water some distance astern, and this goes on with unbroken regularity, hour after hour, day and night. In the tank is a gang of men who watch each turn out to prevent its carrying up a neighbor, and remove the boards as flake after flake goes steadily out. To subdue the centrifugal force developed by the cable, a frame-work of iron rings placed at distances, one above the other—technically known as a "crinoline"—is lowered down the tank as the flakes diminish; in this way the cable is prevented from lashing out round the tank as the outer turns of a flake are reached. The foreman of the watch is stationed over the tank, other hands are at the brakes of the paying out gear, the engineer in charge of the deck posts himself near the drum and dynamometer so as to keep a close watch on the strain and the rate of paying-out, his assistant keeping a running record of these data; it is a case of a place for every man and every man in his place. The watches are changed every four hours. At night the quarter deck is brilliantly illuminated by electric light, and the work is carried on with the same ease as during the day. In the testing room, as I have already described, a careful watch is being kept on the electrical conditions of the cable, and every now and then the chief electrician and engineer-in-chief exchange notes as to developments in their respective departments.

A rather ticklish operation is changing tanks, *i. e.*, starting on a fresh tank when the contents of one are exhausted. The cable is shipped, of course, in different lengths, and the ends are spliced together at sea according to requirements. When a long section has to be laid, involving a consumption of all the cables in two or more tanks, the lengths in the different tanks have to be spliced beforehand so that when one tank is exhausted, another can be drawn upon at once. The part containing the splice is coiled down on top of the full tank, the cable from the nearly exhausted tank being led up outside the coil and kept out of the way by being passed through an angular piece of iron, bolted on to the topmost ring of the crinoline. The part of the ring which forms, so to speak, the base of the triangle enclosed by the angular piece of iron, is pivoted so as to admit of its being opened when the last turn comes out of the tank, thus freeing the loop or bight, and leaving the cable free to be drawn out of the next tank. Previous to changing tanks, when there is about a flake left in the old tank, the ship is slowed down; by the time the men in the tank sing out "three more turns," "two more," "last turn," "bight coming," the ship is barely moving, and the bight can be straightened out, and given a fair lead through the machinery with perfect ease. Then the splice comes along. A splice is always looked upon as a weak spot and treated with the utmost consideration, but the cable hands are such adepts at making them that they are generally as strong as the main cable. However, a splice is of course more bulky than the rest of the cable and might foul in some part of the machinery, so it is watched carefully overboard, and then the new tank is fairly started, and the usual speed of paying-out is resumed, the rate of paying-out varies from six to sometimes eight or nine knots an hour, according to depth of water, weather and other circumstances. After a few days of steady paying-out, the buoy on the shore end is sighted and the ship is carefully manœuvred up to the buoy, a very delicate piece of navigation if there is any sea or wind to speak of as the ship by this time is light and well out of the water. The buoy being brought well under the bows, a boat is lowered and a line is made fast to the mooring-chain, the chain is unshackled and the buoy towed off to be hoisted on board, and the picking-up gear starts heaving-in on the line, bringing up the chain and mushroom anchor with the cable attached. The cable is made fast with stoppers and the end is opened up and handed over to the electrical staff to test. The test being satisfactory the main cable is brought round outside the ship to the bows, made fast and cut, and the joint and splice are immediately commenced. The jointer and his assistant, with solder, gutta percha sheating and compound rapidly unite the two ends, and the joint, being pronounced of satisfactory workmanship, is tested electrically. That is, we make the jointer believe we test it, because with marine instruments and neither end of the cable available, it is not a very easy matter to really test a joint. The joint being passed, the splice is begun, and this is a somewhat longer job; the splice is generally about 30 feet long; that amount of core having been cut out of one of the cable ends the armor wires are unlaid, and then laid into spaces left by wires being taken out of the opposite end, butted together at intervals of a few feet, lapped with smaller wires, and finally the entire length of the splice is served with spun yarn. The whole operation occupies about two hours.

Dropping the final splice overboard is a delicate operation, as it must be remembered that there is a large bight or loop of cable on board, which has to be let go and take its chance of reaching the bottom in safety or kinking and parting on the way down. Such an accident, however, very rarely happens, although in deep water it has been known to occur. A stout rope is bent on to each side of the bight the stoppers are removed and the bight is carefully lowered until it is well clear of the ship; a man armed with an axe stands over each rope and at a given word the two are severed, simultaneously and away goes the splice. The chief electrician then makes for the cable hut on shore and the final test is taken, the cable generally being found in perfect condition.

I am afraid I have already overtaxed your patience and so far I have said nothing of repairing and of the various methods of operating submarine cables. Regarding this latter point it is scarcely possible to speak of it in detail, as it would take too long to describe the various instruments in use. That most used to-day is the syphon recorder, with the principle, of which you are more or less acquainted. Many cables are still operated by the mirror, although the recorder has replaced it to a very great extent. The mirror, perhaps, is a little the more rapid, but the recorder insures greater accuracy. On some cable worked by the mirror, where the signals are good and the traffic not very great, one operator can work the mirror as the spot of light is thrown on to the message pad and the operator can follow the movements of the spot without looking at it. In fact, the secret is, not to look at it. If you watch the spot your pencil goes anywhere but where you want it to go, but by watching your pencil you can see the spot moving just as well as if you were looking directly at it. If the cable is a very long one, giving bad signals, or if the traffic is very great, two operators have to be employed for receiving, one to read and another to write. Then the errors creep in; P's are heard instead of B's and M's for N's, and as there is no "slip" to check the message by; repetitions have to be asked for and traffic is delayed.

It is astonishing what a difference there is between mirror signals on a short cable of a few hundred miles and those on a long one of a couple of thousand. A friend of mine, who had been an operator on the west coast of South America, and was a first-class mirror man, on coming home to England applied for a position in one of the Atlantic cable companies. He was asked if he could read mirror, and replied, "Oh, yes: thirty words a minute;" whereupon the manager said: "Well, if you can read our mirror you will get a salary of £14 a month, but if not, and we can only put you at Morse, we shall only pay you £8 a month." My friend hied himself off to the Irish coast, confident of his £14 per month—$70 a month is a good lot in the wilds of Ireland, where you can't spend anything unless you subscribe to the Union League Fund—but when he got to the station he found that our mirror was very different to those that he had been accustomed to. Instead of the movements being clear and well defined, the spot was wandering continually all over the scale and the signals were striving to make themselves seen through the wanderings and kicks and jerks which the spot was chronically affected with. My friend had to confess himself beaten (although he had been reading mirror for five years), and had to content himself with $40 a month—which is not much even in Ireland—until he had mastered the eccentricities of that diabolical spot. Short cables are worked by Morse in the same manner as land lines. No system of automatic fast-speed transmission has yet been adapted to any but very short cables, but I have lately seen that experiments are being made tending in that direction.

With regard to repairing submarine cables I am afraid that it is too late for me to say much. Repairing is the most difficult and thankless part of a cable engineer's work. Landing shore-ends and paying-out are mere pastimes compared with repairing in deep water. There is a considerable element of luck in it, too. Sometimes the cable is hooked at the first drag, and at others wears weeks are spent in dragging to and fro over the line of the cable without ever getting a bite.

The *modus operandi* is to lower a grapnel over the bow, the grappling rope being passed under the dynamometer and taken to the picking-up drum. The ship then steams slowly across the line of the cable, dragging the grapnel along the ground. If the bottom is soft the cable may soon be hooked, and the steady rise of the strain on the rope shown by the dynanometer indicates the fact. If the ground is rocky and uneven the grapnel may jump over the cable fifty times without even touching it. The long delays incident to repairing expeditions sometimes renders repairs immensely expensive, and the expense is often increased when the broken ends have drifted apart, or much of the cable is damaged, and a length of new cable has to be laid. Some repairs to one of the Atlantic cables, not many years ago, cost over $400,000. The ship was out for weeks on the Atlantic, and had to put back to port for coal without having accomplished anything. Everybody on board was, after a time, in the most miserable spirits imaginable. After a week or two of non-success, they got to such a state that every one had told all his stories, the unlucky ones had lost at cards to the lucky ones all their money, and all the pay that they expected to receive for the expedition, and they all grew to hate the sight of each other; assembled only at meals and devoured them in silence, each man, except those on watch, retiring to the solitude of his own cabin afterward; and all were heartily glad when the cable way finally grappled and repaired, and they were able to get back on shore. All repairing expeditions do not have such a bad time as this one did, but as a general rule repairing is difficult and ungrateful work, attended by all sorts of delays and accidents, and no splice is so gladly dropped overboard as that which terminates a troublesome repairing job. In drawing to a close I must apologize for the shortcomings of this paper. I feel that I have omitted many important and interesting points and perhaps I have treated of others with undue prolixity and discursiveness. But I am somewhat in the position of a man who attempts to discuss, say, electric lighting, in a single paper. It would be impossible to describe dynamos, lamps, conductors, transformers, switches, accumulators and installation work and superintendence in a single evening. Submarine telegraphy is a subject about which one might very well write a big book; in fact such a big book has lately been published, and I am sorry to say it is in the French language.

According to the official report of the International Bureau of Telegraph Administrations, issued last fall, the submarine telegraph system of the world consists of 120,070 nautical miles of cable. Of these 12,524 miles belong to Government administrations, and 107,546 miles to private companies. The total cost of these cables is in the neighborhood of 200 millions of dollars. The largest owner of sub-marine cables is the Eastern Telegraph Company, whose system covers the ground from England to India, and comprising 21,860 miles of cable. The Eastern Extension, Australasian and China Company, which exploits the far East, has another 12,958 miles. Early in last year the system of West African cables, which started from Cadiz, only six years ago, was completed to Cape Town, so that the dark continent is now completely encircled by submarine telegraph. It has required more than 17,000 miles of cable to do this, and several companies with more or less, aid from the British, French, Spanish and Portuguese governments, have been occupied in carrying out the work.

The cable fleet of the world numbers thirty-six vessels of an aggregate gross tonnage of 53,802. Of these, ten ships belong to the construction companies, their aggregate gross tonnage being 28,143, or more than half that of the entire fleet. The other twenty-six vessels are repairing ships, belonging to the different governments and telegraph companies, and they are stationed in various ports all over the world, to see that Puck's girdle is kept well buckled.

Fatal Gas Explosion.—Two men were killed, two were fatally and severely injured by the explosion of gas in the condenser room of the St. Paul, Minn., Gas Works, on the 18th inst.

How our Paths May be Made Paths of Peace.*

BY H. W. POPE.

Previous to the introduction of the telephone, the standard of outdoor or pole line construction may be said to have been that established by the Western Union Telegraph Company, or organizations that from time to time came under its control by purchase or consolidation. The lines of these companies were never of a superior character, nor in any way comparable at the time with those erected in European countries, and it was not until after thorough inspection and exhaustive tests were made by a prominent English electrician, employed for the purpose, that extensive alterations and improvements were made, greatly increasing the efficiency of the wires, and, naturally, their more economical operation.

The construction of a most excellent line along the route of the Pennsylvania Railroad, between Jersey City and Philadelphia, by the management of the American Union Telegraph Company, previous to the absorption of that company, marked a new era in line construction; but, notwithstanding the brain that inaugurated this departure afterward controlled the great competing company, the standard thus established was never closely followed by them.

However parsimonious the Western Union Company may have been in their construction and maintenance expenditures, telephone, electric light and similar corporations would have been greatly enriched by literally following in their footsteps. They encouraged and provided for increased conductivity and tensile strength and fair insulation, and established a department of competent and reputable electricians and experts, to insure a systematic compliance with specifications and requirements, destroying the evil that had grown into prominence, which permitted officials to exploit hobbies of their own to the detriment of the business and the ridicule of electricians.

To those of us who have been identified with electrical interests for the last quarter of a century, there seems to have been no notable improvement in line construction, except as shown in the recent inter-State lines of the American Telephone and Telegraph Company. The introduction of the telephone brought into the electrical field a very large class of workers devoid of electrical knowledge or experience. To this class, the methods employed and the standard of construction prevalent were superior to the necessity and requirements of the telephone.

This opinion and the lack of sufficient capital to properly exploit the telephone business was primarily the cause of the introduction of poor material and workmanship, as well as the small wire and insulators, together with porcelain knobs and cheap insulation.

With the experience of our predecessors in the electrical field, and with the knowledge of the character of the current we were handling, it would seem as if a superior character of construction and insulation would have been deemed imperative; yet, with the exception, perhaps, of conductivity, everything in connection with the conducting of the current was inferior to that previously used by corporations employing harmless voltage. That such was the case is due somewhat to causes similar to the introduction of the telephone—but the use of cheap insulation, what is popularly and properly known as "undertakers'" wire—was due wholly to the ignorance and stupidity of underwriters' officials, to whom many of us protested repeatedly against its use.

The accumulation of poles, the inferior character of the materials used, and the utter disregard of public considerations or the character and beauty of the surroundings, gradually molded public opinion against poles and wires in general, and electric lighting in particular.

The desire of electrical manufacturers to crush their competitors, was accelerated by distressing accidents, until every publication throughout the land magnified the dangers of electricity, depreciated our property, and retarded the progress of electric lighting and electric propulsion beyond our comprehension. To this condition of things we most now devote our attention—adverse legislation is cropping out in nearly every State in the Union, tending to regulate voltage—to bury the wires, and to accomplish other reforms too numerous to mention. In view of all this, it should be the aim of electric lighting corporations to so reform the existing methods of construction as to show a decent regard for public opinion as to safety and the appearance of their structures in the public thoroughfares. By a sincere effort in this respect, beneficial improvements can be introduced without necessitating large expenditures, and the clamor for the removal of overhead wires reduced to a minimum. Where there happens to be an unnecessary aggregation of poles, endeavor to perfect an arrangement whereby poles may be occupied in unison, and as many poles removed as circumstances will admit. Such a course will reduce your maintenance expenses, and create for you favorable public opinion. In the erection of poles, considerable attention should be devoted to their design and proportions, and the character of finish, to the end that the structure may be made pleasing to the eye. The removal of a pole because of deterioration, or with a view to the erection of another with greater capacity, should be followed by the substitution of one in every respect superior in strength, design and finish.

The question of expense, as compared with common poles, should not be allowed to deter you from the ultimate purpose of replacing your entire line, especially in cities or towns where the burial of wires would be a financial impossibility.

To those familiar with the recent excellent structures of the Long-Distance Telephone Company, or those of some of the electric railways, the possibility of improving upon the present methods of construction will readily suggest itself. While it is not advisable to use iron poles, combination of wood an iron can be used to advantage in many instances. The practice of introducing wires into the front of buildings is an objectional method, and should be discouraged when possible. This can often be obviated, as well as hundreds of other similar disreputable and unsightly practices, if given a little personal attention and consideration by the genera manager.

It will be frequently discovered upon investigation, that lines of poles erected in the streets in front of buildings can be removed to an alley or street in the rear, or constructed over private rights of way by the payment of a nominal considerasion. Where such a condition of things is possible, it will be found desirable and preferable to incur the expense and make the change voluntarily. Reduce, rather than augment, the number of poles which at the best cannot be else than unsightly. Provide every pole with iron steps and paint the poles as thoroughly as you would a house, and select colors that will not make your poles more conspicuous than they really are.

In so far as a neat, well-designed and substantial brick station reduces your rate of insurance, gives character and substantiability to your investment, so will the improvements suggested—how-

* A paper read before the National Electric Light Association, Kansas City, February, 1890.

ever small and insignificant at first—if properly and sincerely carried out, win for you favorable consideration and fair treatment, and enhance materially the value of your property, besides tending to postpone indefinitely the removal of overhead wires.

It should be the aim and policy of all electrical corporations to constantly improve the condition of poles and lines—giving as much attention to their strength and beauty as to their perfection electrically. The assumption that such a course is unwise, because of the theory that sooner or later all wires must be buried, is wrong, because it is questionable whether such an extreme will be reached, especially in cities and towns of small population Every day that you delay these improvements you encourage adverse criticism and hasten adverse legislation, State and municipal.

Subways and underground structures are not pleasant things fo the strongest of us to contemplate, and where, heretfoore, you have had only the gas interests to advocate these measures, you now have competitors in the electric light business, urging legislation against overhead wires with the same earnestness as inventors and manufacturers of cables and subway appliances. These interests are better equipped with facts and figures than has been the case heretofore. A policy such as outlined, and a vigorous State organization of electric lighting companies. will protect our interests from any severe measures at the hands of the general public,

The Practical Working of the Electrical Subways of New York City.*

BY WILLIAM MAVER, JR.

Knowing very well the widespread interest that has attended the placing of wires underground in New York City, I have been glad of the opportunity to gather and prepare for presentation to you this evening such data and information relating to that subject as I have thought would be, and as I hope may be, found of the most value.

I observe that our worthy secretary has announced me in the notice of the meeting as the electrician of the Consolidated Telegraph and Electrical Subway Company, and quite correctly so. I desire to say, however, perhaps unnecessarily, that I have prepared this paper in my unofficial capacity, and am, of course, alone responsible for what may be contained therein.

The customary reply to an inquiry as to what is the best arrangement for an electrical subway is, "Build a tunnel under the streets and place the wires on the walls within easy access of workmen and into such a tunnel put also the gas and water mains, etc."

Assuming that this would be a satisfactory solution of the underground question if it could be arranged, let us consider what the cost of such an arrangement would be.

It has been estimated that a subway suitable to contain all the electric wires, gas and water mains of New York city would cost $430,000 per mile. This for Broadway alone, from Bowling Green to Central Park, would mean an outlay of about $2,150,000, and if such a tunnel were to be built throughout the entire route of the now existing electrical subways of New York city, the bill would foot up to nearly $30,000,000.

This amount, it will, I think, be generally admitted, is virtually prohibitory of any such subway at present, and if that is the case the fact will perhaps make those who have had preconceived ideas in favor of a universal tunnel scheme more tolerant of the electrical subways we have, the practical working of which I am to endeavor to describe this evening.

When the first whisperings of a desire on the part of the public or press to have electric wires in the large cities go underground were heard in this country, it will be remembered the telephone people with one accord admitted that it would be quite feasible for the telegraph and electric light people to operate their wires underground, but claimed that for them to attempt to operate their circuits thus meant irretrievable ruin. Equally convinced also were the telegraph people that while it would be very easy for the electric light companies to work their circuits underground, it was quite out of the question that telegraph wires could be operated successfully in subways, since the increased electro-static and electro-magnetic effects would completely destroy quadruplex and fast automatic telegraphy. And no less emphatic was the opinion of the high-tension electric light people that the telegraph, the telephone and the low-tension electric light systems could, if required, all go underground without detriment, but it was utterly impossible for them to do so and at the same time to operate their circuits successfully.

New York City was no exception when the time came to place the wires underground. Gradually, however, the telephone yielded—more gradually the telegraph, but more tenaciously the majority of the high-tension people clung to their statements, and the experiences of the cities of Chicago and Philadelphia, especially Philadelphia, and elsewhere were cited as evidence of the futility of any attempt to operate high-tension currents underground. These experiences were held to show that no insulation could be procured which would withstand the pressure of the high electromotive force employed on high-tension circuits. In addition to this it was also asserted that the requirements of the Subway Commission regarding the insulation resistance of the underground conductors was high beyond all precedent and unobtainable in practice, and that even if such insulation could be obtained it would be impracticable to make tests of the conductors, showing them to possess the insulation resistance required by the rules.

It is very far from my intention to go into a history of the opposition offered by the different electrical companies to placing their wires underground, and in so far as I have just alluded to it I have done so for the purpose of quoting in a general way some of the reasons given by the companies for this opposition, and this only, that we may see how far the surmises of those who were thus averse to placing wires underground have been verified by actual results.

It is told of a certain noted geologist that when a specimen of gold quartz, which had been found in a locality where he had stated no gold would ever be found, was shown him, he remarked that if it really had been found there, nevertheless it had no right to be there.

I can imagine that there are many persons—perhaps not in this room—but somewhere, who, if told that the telephone, telegraph, high and low tension electric light circuits, and even the "deadly" alternating circuits are to night in this city working successfully underground in the same streets and on the same side of the streets, would reply, "If they really are working successfully there they have no right to be."

In preparing this paper I have found that the subject has almost naturally arranged itself under the following general headings, namely:

The type of conduits used in the subways,
The drawing in of cables.
The methods of distribution.
The cables employed in the subways.
Present condition and probable duration of cables.
Joints.
Lead covered cables.
Insulation and tests.
Alleged dangers of the subways.
Gas in the subways.
General remarks.

I have been unable to obtain, with any degree of accuracy, the extent of electrical subways or the amount of wire placed in them in the cities of Europe, and, therefore, I cannot say definitely how New York to-day compares with such cities as London, Paris and Berlin in that respect. But I incline to the belief that it may be found that New York will fall but little, if at all, behind those cities. In New York City to-day there are 73 miles of electrical subways, and 1,017 miles of ducts. In these ducts there are 10,906 miles of telephone wire, 945 miles of telegraph wire, including fire alarm telegraph wires, and 457 miles of electric light wires. These subways have a capacity for about 45,000 miles of telephone and telegraph wires and 2,000 miles of electric light wires.

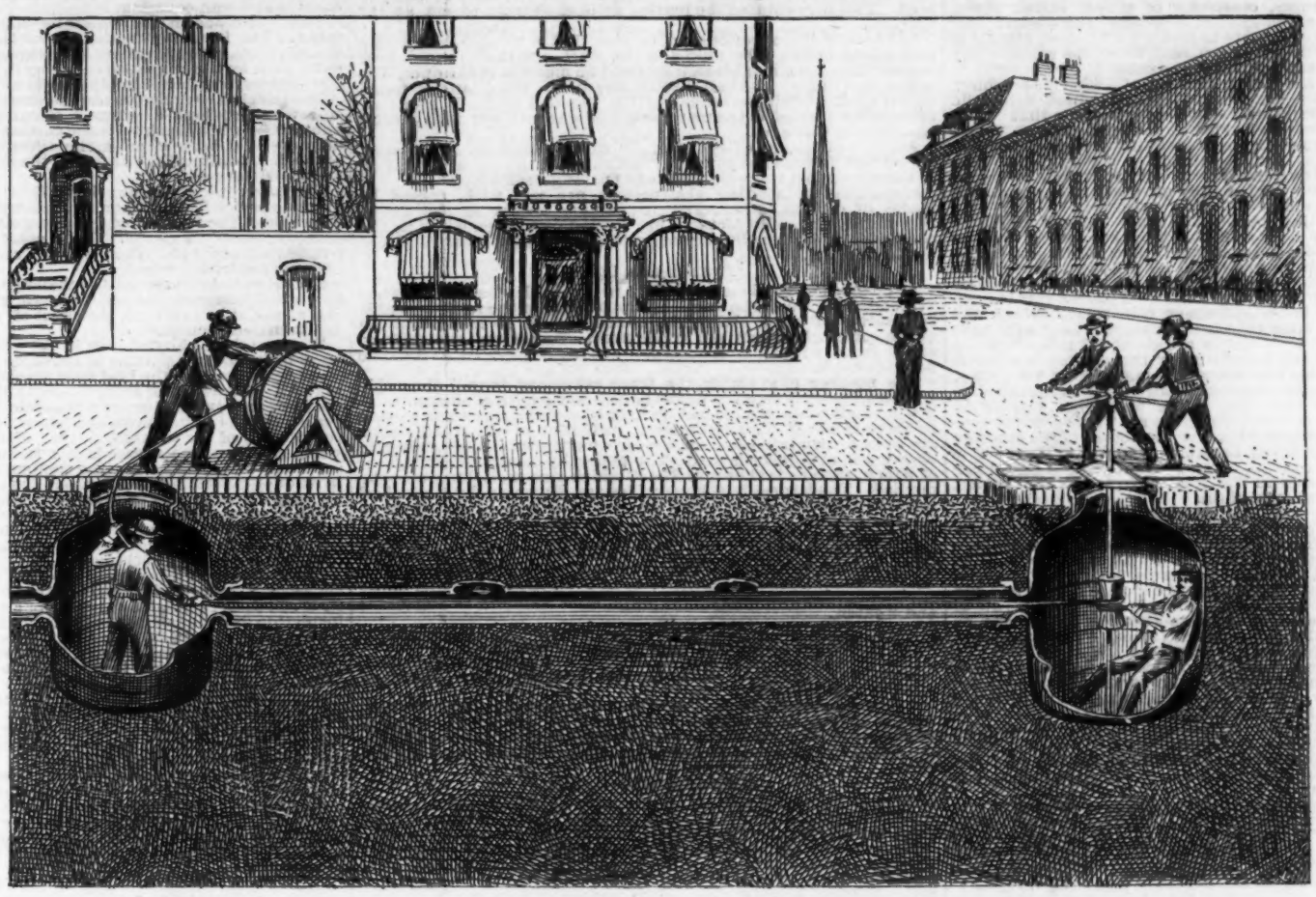
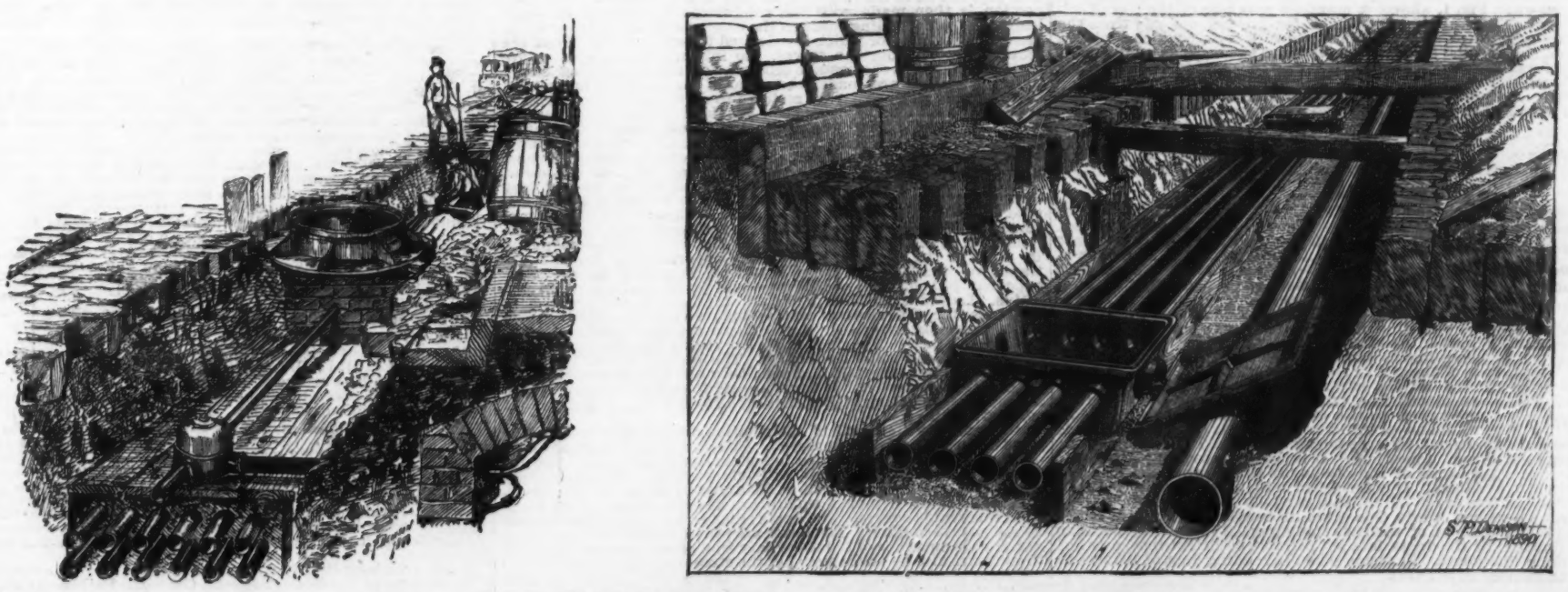


FIG. 2.—DETAILS OF WORKING IN THE NEW YORK SUBWAYS.



FIGS. 1 AND 5.—DETAILS OF WORKING IN THE NEW YORK SUBWAYS.

Conduits.

There are in the New York electrical subways eight different conduit systems—namely, the Dorsett, the Wyckoff, zinc tubing in hydraulic cement, sheet iron cement-lined pipe, wrought-iron pipe in hydraulic cement, wrought-iron pipe in asphaltic concrete, the Edison iron tube and the Johnstone sectional cast-iron conduits. All of these conduits have been frequently described; I shall therefore just briefly refer to each.

The Dorsett system consists of blocks formed of a material the ingredients of which are pitch, coal tar and fine gravel. The blocks are molded, with tubular openings about 2¼ inches in diameter from end to end. The blocks are about 4 feet long and 1 foot cross

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section. These blocks are placed end to end in the trench, and are joined together by pouring between the ends a liquid compound of pitch and tar, which speedily hardens. This compound is prevented from entering the ducts by sleeves, which are placed in each duct between the junction of every two blocks. There is about one mile of this conduit, containing 16 miles of ducts, on Sixth avenue. It is used for telephone and telegraph conductors. This conduit was laid three years ago. So far as I can learn, it is in a fair state of preservation to-day—but not perfect; the blocks having in some instances sunk, and thus put the ducts out of alignment. It may be noted here that guide ropes, consisting of ¼-inch tarred hemp, which were laid in these ducts when this system was constructed, to be in readiness when cables were to be drawn in, show plainly in numerous places signs of deterioration, said to be the result of dry rot, combined with the gases found in the ducts.

The zinc tube conduits are laid in 58th street. The zinc tubing was intended to serve simply as a mold around which hydraulic cement concrete was to be placed, with the expectation that when the zinc had corroded, the tube formed by the solid cement would remain intact. About one mile of this conduit has been in successful operation for three years, but the difficulty attending *the construction* of a conduit formed in this way was so great, owing to the frailty of the zinc tube, which readily gave way under moderate pressure, that its use has not been further extended.

The sheet iron cement-lined pipe conduits are made in single or multiple tubes of 2, 4, 6 or more ducts, as may be required and in lengths of 8 feet. The tubes are connected together by a ball and socket joint. These conduits are made as follows; a sheet iron tube 8 feet in length is held vertically; inside of the tube is placed a smaller brass tube, and semi-liquid cement is poured into the annular space between the brass and sheet iron tubes. When the cement has solidified the brass tube is withdrawn. The cement tube is then ready for the subways. There are about 113 miles of ducts of this conduit in the subways, and during the coming summer it is expected many times this amount will be laid in New York City.

There are about 15 miles of creosoted wooden ducts in the subways known as the Wyckoff conduits. These ducts are formed of wooden piping similar to ordinary pump logs. There are lead-covered telephone cables in these ducts, and the action of the creosote upon the lead covering is being carefully watched. These ducts have been in operation for three years. I am informed that detrimental effects are noticeable in the lead covering of the cables, which is alloyed with 3 per cent. of tin.

The bulk of the subway conduits consists of wrought-iron pipe laid in hydraulic cement concrete. These pipes are 20 feet in length and vary in diameter from 2 to 3 inches. The thickness of the iron is .217 inch. In laying all of these pipe conduits, the bottom of the trench is first leveled to grade; planks are then set against the side of the trench to sustain it. A layer of concrete is then laid and rammed in the bottom of the trench. On this is placed a row of iron pipe, next a layer of concrete, then another row of pipe, and so on, until the desired number of layers is attained. The number of pipes in a row depends upon the topography of the street and the location of existing gas and water pipes which it is desired to avoid, and the number of rows upon the total number of pipes desired to be laid in a given subway. In order to add strength to the mass and to protect the ducts from mechanical injury, the concrete is applied more thickly on the bottom, top and sides of the subway than between the pipes. There is placed over all a two-inch yellow pine planking, heavily creosoted, to further protect the conduits against injury, from picks, crow bars, etc., in the event of future excavations in the streets.

The wrought-iron pipes are joined end to end by a coupling screw joint with a tapering or vanishing thread. By the use of this form of thread, I am informed the rate of laying this piping is increased 50 per cent. These tubes are delivered free from burrs and have a smooth inner surface. The pipes are sometimes asphalted to prevnet rusting, but should they in the course of time rust, it is expected, as in the case of the zinc tube, that the concrete will preserve the shape of the duct intact. There are close upon 550 miles of wrought-iron piping in the subways.

The facility with which a pipe conduit conforms to the varying condition of the crowded streets of large cities, as found in the process of trenching, is one of its chief advantages.

The main reasons which have led to the extensive use of wrought-iron piping in the subways are its great strength, its adaptability to varying conditions of the street and the rapidity with which it can be laid.

The Edison system consists of wrought-iron pipe in which are placed the copper conductors or rods. These conductors are wound with rope and the pipe is filled with an insulating compound of Trinidad asphaltum, rosin, paraffin and linseed oil. These iron pipes are laid directly in the earth. There are about 50 miles of this pipe now laid in New York City.

The subways are in many cases on both sides of a street, and, as a rule, the telegraph and telephone wires are assigned to ducts on one side of the street, and the electric light wires to ducts on the opposite side; but in numerous instances the electric light wires are operated in distributing ducts on the same side of the street as the telegraph and telephone wires, and without detriment to the latter.

Manholes.

Access is had to the conduits of the New York subways by means of manholes, placed at an average distance of about one-twenty-fifth of a mile apart. The manholes are, with a few exceptions, built of brick laid in concrete cement, with hydraulic concrete bottom. The outside of the walls is coated with cement, to prevent moisture and gas from penetrating.

Access to the manholes from the street is had through the cast-iron head which is set on the brick work and which is provided with double covers. The upper or street cover weighs about 350 pounds. The lower cover is provided with a rubber gasket to prevent ingress of street water into the manhole. This cover is funnel shaped in order that any water which may enter through the upper cover may be drained away from the gasket. The lower cover is screwed down upon the gasket by a gun metal bolt and cross bar. The upper cover is loose upon its bearings. The ducts enter the manholes at a point easily accessible to the workmen while standing on the bottom of the manhole. The average width of the manholes is about five feet and varies from five to ten feet in depth. The drawing, Fig. 1, shows a standard manhole of the New York subways. The hand blower used for driving out gas from the manholes is shown, also the iron framework or cage which is placed around the opening to the manholes when the cover is removed.

The foregoing-mentioned conduits may be considered as belonging to the regular subway system of New York City.

There are, however, several other conduits in operation in this city, namely, the Brooks, the Western Union, and about five miles of telephone cable laid in wooden boxes filled with sand. The Brooks system has been so repeatedly described I need not further allude to it. The Western Union subway consists of an iron pipe about six inches in diameter into which wires have been drawn.

Rodding.

The electrical subways of New York City, with the exception of the Edison system, are of the class known as the drawing in and out systems. The first process in drawing a cable through a duct which is not easily accessible except at its ends in the manholes is obviously to provide a means of drawing in the cable. This is done by a process technically termed rodding, which consists of pushing rods through the duct from one manhole to the next. A rope is then attached to the end of the rod and the rod is withdrawn bringing the rope with it. This rope is then employed to haul in the cable. As some of the manholes are over 500 feet apart, and it would not be convenient to procure a continuous wooden rod of that length, rods of about four feet in length, furnished at one end with a screw and at the other end with a screw socket, are used. These are placed in a bunch in the manhole and are attached by the screws one to the other, as many as are required to reach to the distant end of the duct. The rods are then detached, as they are drawn out, by unscrewing the ends. This is a specimen of this form of rod. (Showing.) It is the one most generally used. There are other forms of rod also in use in the subways. The one shown is one of them. It is furnished with a slot into which the T end fits, but into or out of which it can only go at a certain limited angle. Therefore, while this joint or connection is quite loose, there is no likelihood of the rods coming apart in the duct because the diameter of the ducts does not permit a sufficient movement of the rod at the joints. The time taken in rodding duct of 300 feet in length is about 20 minutes.

Continuous steel wire rods about one quarter of an inch thick and from 400 to 500 feet long are also used for rodding the ducts. These rods are mounted on a reel about 6 feet in diameter, which is placed adjacent to a manhole, and from which it is reeled off as the rod is pushed through the duct. When this operates freely, it is more expeditious than the wooden rod methods just described, as the time taken in jointing up the rods is saved, but it is found that the wire occasionally buckles in the duct, and, furthermore, it is more apt to be caught by any obstruction or unevenness, than are the wooden rods, so that by many the latter are employed as being the more expeditious, all things considered.

There is also another means of rodding sometimes employed, which consists of a long spiral steel rod, the spiral of which is about one inch in diameter. On the circumference of the spiral small wheels are mounted to ease the friction. This rod is also placed on a reel and wound off as it is fed into the duct. This spiral, while quite elastic, is yet capable of withstanding considerable pressure. This rod is pushed into the duct in the usual way. The expense and the weight of this form of "rodder" is somewhat against it, although I am informed that by its use a duct can be rodded in one-half the time required by the screw rods.

Before those employed in the work of drawing in conducters into subways had devised and settled down to the forms of rods just described, many bright minds were at work on the question of how to rod the ducts. The scheme of tying a string to a rat's tail and sending him through the duct with a ferret after him was tested practically in Brooklyn, I believe, but the plan was not generally adopted. In the case cited, it is stated that the ferret overtook the rat, and stopping to eat him was overcome by the gas and asphyxiated. This necessitated the tearing up of the street to get at the remains.

In Chicago, it was seriously suggested that a wooden ball with a string attached to it be placed in the duct, and that then a hose connecting with a neighboring hydrant be inserted in the duct. The water was to force the ball through the duct. This plan was found to work successfully so far as getting the ball through was concerned, but it flooded the manholes, and was not put into general use, even in Chicago.

Another inventor devised what he called a mechanical creeper, which was designed to advance itself through the ducts by putting out arms against the walls and thus pushing itself along.

Sometimes in rodding obstructions are met with, caused by pieces of cement, stone, dirt, etc., gaining access to the ducts. Sometimes, also, obstructions are caused by uneven joints in the conduits. Ordinary obstructions are removed by a mandril placed on the first rod.

Drawing In Cables.

After the rope has been attached to the cable, the latter is then "threaded" through the duct. The attaching of the rope to a cable is a matter of some skill. The connection is so made that the strain comes chiefly on the conductors. To prevent the cable or cables from twisting as drawn in, a swivel is inserted in the rope near the cable.

The manner of applying the force necessary to pull the cable through the duct depends upon the size and length of the cable. If it is a small cable, say 300 feet in length, it can be drawn in by two or three men. If it is a large cable, or if four or six small cables are to be drawn into one duct, as is frequently done, more elaborate drawing-in apparatus is used This generally consists of some form of winch, such as is shown in Fig. 2, which very well illustrates the method. The largest telephone cables are drawn in by a winch of special construction, in which the power is transmitted through the intervention of wheel gearing. As a rule, it may be said that in the matter of drawing cables into the ducts the work has been satisfactorily performed. In a few instances mistakes have been made, as in the attempt to draw too many cables into one duct—the old problem of putting a 3-inch bung into a 2-inch hole—and in the attempt several lengths of cable have been jammed in the ducts and injured.

As many as six electric light cables, No. 4 B. & S. conductor, have been repeatedly drawn at once into a 3-inch duct.

It is not deemed advisable to draw cables into or out of ducts over cables already laid, but in cases of necessity it has been done without injury to the cables.

As the weight of a No. 4 B. & S. lead covered cable, is for 300 feet, say 250 pounds, an idea may be obtained of the force required to draw in six such cables. I am informed that cables weighing in the aggregate 5,510 pounds have been drawn at one time into one duct.

Methods of Distribution.

It is, of course, a comparatively easy problem to arrange an electrical subway for trunk line circuits. The difficulty arises when the question of distribution of the current from the main conduits is to be considered, as when, in the case of the telegraph and telephone service, it is desired to furnish city customers with circuits, and in the case of electric light service when it is required to make house to house or street lamp connections.

In the case of telegraph and telephone distribution subsidiary pipes or ducts are generally led from an adjacent manhole to the front or side of buildings, whence the cables are continued to the roof of the building or to the back yards, from which latter points the circuits are radiated as required.

The cable of the telephone company is generally made up into 50 pairs. When this number of circuits is not required in one block or series of blocks, the cable is forked in the manhole, one portion of the conductors being led in a smaller cable in one direction, another portion elsewhere, as may be required. This method of distribution has been found convenient and satisfactory.

Distribution of the electric light current is effected in several different ways in the New York subways. For street arc lamps the circuit is usually looped from the manhole to the lamp post through a subsidiary iron pipe.

For easy access to houses and to lamps in the middle of blocks distributing ducts are laid above the trunk ducts as near the surface of the street as practicable. The average distance from the surface of the street being perhaps 18 inches.

The Johnstone sectional conduit, Fig. 3, has hitherto been the most extensively employed for this purpose in New York City. This conduit consists of sections of cast-iron ducts about 5 feet in length. The sections are placed directly above each other and are held together when in position by removable clamp pins. The upper section rests in a groove in the lower section. Each section of the conduit is divided into from two to six or more compartments or ducts—depending upon the size of the section—the ducts being formed by removable partitions or slats held in position by suitable channels or grooves within the sections. Opposite each house or every alternate house a handhole is provided in the upper section of the conduit. This handhole consists of a removable cover, about 2 feet in length, on the upper section, and the side of the section at this point is provided with a branch or spigot.

This conduit is laid directly in the earth—not in cement. When it is desired to obtain access to a conductor to tap or loop the circuit into a building, the paving and earth are removed from the street and the cover of the handhole is lifted, thus exposing the conductors in the ducts. A 3-inch iron pipe is run from the branch at the handhole to the basement or vault of the house or to the lamp post with which connection is desired to be made. This iron pipe fits on to the spigot at the side of the conduit. The connection is then made with the conductors by splicing on short lengths of cable leading through the iron pipe to the house or lamp. Should the conductor which it is desired to tap be at the side of the section remote from the spigot, the intermediate partitions are removed to permit the passage crosswise of the connecting cable. After the joints are made, the cover of the handhole is replaced and the earth and paving are restored to their normal condition.

When a handhole has not been provided originally at a point where access is desired to a conductor in the conduit, the entire upper section is removed and replaced by a half section containing a handhole cover and spigot. This work can be done in a short time. The sections in use for this purpose are, in some instances, somewhat small for ease in joint making, especially, as but very little slack is available when T joints are to be made, and, in future, larger handholes will be provided. These conduits are presumably made air and water tight at the junction of the two sections and, at the ends of the ducts, by the use of plumbers' putty. In view of the number of supposed opportunities for the entrance of moisture at these junctions, it would be naturally expected that this type of conduit would be in a chronic moist condition. Indeed it has been predicted of it that the ducts would act as canals for the surface water; but, as a matter of fact, these ducts are almost invariably dry. There are two theories given to explain this fact. The first, that in reality the plumbers' putty makes an air and water tight joint. The second, that if the joints are so imperfect as to admit water, they are quite capable of permitting its escape also. It must be said that this system has been found of much utility in the practical distribution of electric light current in this city.

More recently a method of distribution in which wrought-iron pipes are used has been employed. This consists of a row of three or four iron pipes laid, like the Johnstone conduit, as near the surface as possible—in the earth, without concrete. Opposite every party wall, or, in other words, at distances of about 50 feet apart, iron boxes about 18 inches square are placed. Then these boxes have removable covers. The ducts enter at the ends of the box but do not pass through it. The boxes are provided with side openings also for the entrance of the subsidiary iron pipes. Access is had to these boxes also by the removal of the street paving and earth.

This method of distribution has, like the one just described, been found satisfactory. Certain mechanical improvements in the construction of both are, however, desirable, and are contemplated.

When it is desired to cross a street to reach customers subsidiary ducts are constructed.

It is frequently remarked, presumably derogatory of the existing electrical subways, that no system of house to house distribution can be considered perfect which requires the tearing up of any portion of the street to obtain access to the mains. This will be granted by any one. The same is equally true of the house to house distribution of gas and water from the street mains. In all of these cases, if the connections were made from the street mains to every house and vacant lot along their routes when the mains are first laid, the necessity for reopening the streets to make house connections would be avoided. But I have yet to learn that this is done by either the gas or water companies, nor have I heard that their neglect to do so has been seriously animadverted upon.

It would, therefore, seem unreasonable that the additional expense of making these connections, which may never be required, should be urged upon the users of the subways by any who have the interests of electrical industries at heart, especially while they ignore the failure of the gas and water companies to make corresponding connections.

The Cables and Insulation Used in the Subways.

In the telephone service in this city, the cables used are chiefly of the type known as the Patterson. This cable is constructed as follows: Ordinary cotton covering is first placed around the wires. After the wires are cabled, a lead covering is placed over them, and paraffine is then forced into the interstices between the conductors and lead covering.

This cable has an electric static capacity of about 0.16 microfarad. The insulation resistance of the cable, laid and jointed in the subways, averages about 100 megohms. The longest stretch of cable used by the telephone company in the subways is seven miles. The greatest number of conductors in any one cable is 100 or 50 pairs.

The telephone service on the underground conduits was impaired somewhat, so long as ground circuits were used, but since the adoption of metallic circuits the service is satisfactory. On the long distance telephone circuits the seven miles of cable is, of course, somewhat detrimental. It is said the loss of efficiency on such circuits is 30 per cent.

The telegraph companies have thus far used chiefly for underground service Kerite, Okonite, Standard Underground and Patterson cables. The Kerite and Okonite insulation, it is well known, are homogeneous compounds. These cables are not lead covered. Of course they could be. The Standard and Patterson are fibrous cables and are lead covered.

Except in the vicinity of the underground steam pipes, the unprotected homogeneous cables have given uniform satisfaction. But as might be expected, the effect of escaping steam upon them has been detrimental.

Fortunately the heated area in the vicinity of the electrical subways is limited to a portion of the down town districts. Investigation has shown that the heat only reaches a harmful temperature in the neighborhood of actual leaks in the steam pipes. Measurements of the temperature of a manhole in the worst section of the heated district have shown as high as 150 deg. to 200 deg. F. Since the starting of the blowers in this district to ventilate the subways, a noticeable decrease in the temperature is observable, and, inasmuch as the steam heating company is achieving some success in its efforts to close up all leaks in the pipes, it is anticipated that the heat difficulty will be eventually removed from the subways.

The users of the Standard and Patterson cables state that those cables are giving very fair service in the heated portions of the subways, although the high temperature, of course, lowers the insulation resistance of the cables.

The average number of conductors in the telegraph underground cables is about 50. The size of the wire used is, as a rule, No. 16 B. W. G. and the outside diameter of a conductor, including the insulation, is 6-32 of an inch. The insulation resistance of the Okonite insulation is about 2,500 megohms; that of Kerite 500 to 800 megohms and that of the Standard and Patterson about 1,500 megohms per mile for the thickness of insulation just mentioned.

Outside of the injury to the cables due to the presence of the steam-heating pipes, no undue deterioration of the telegraph cables in the subways has been noted.

The effect of the increased electro-static capacity of the underground circuits has not caused any marked inconvenience in the operation of the telegraph circuits.

The comparatively low mileage of telegraph wire in the subways is partly explained by the fact that the bulk of the telegraph circuits in New York City are suspended from the Elevated Railroad structures. The Fire Alarm Telegraph cables in the subways do not differ very materially from those used by other telegraph companies. The Fire Department thus far has used Standard Underground cables.

Electric Light Cables in Subways.

In the electric light service in the subways, and I am aware that it is around this that the greatest interest centres, there are, exclusive of the Edison system, four different types of insulation used—namely, the Bishop Rubber Compound, the Standard Underground, the Safety Insulated and the Cobb Vulcanite Paraffine cable. All of these cables are lead covered as a precaution against mechanical injury, action of acids, etc., or moisture. Specimens of these cables are on the table.

The sizes of conductors used in the electric light service vary with every company and with the character of the service. For feeders the conductors range in size from No. 0000 B. &. S. to No. 2 B. & S. For mains from No. 2 to No. 6 B. & S. In many instances No. 10 B. & S. is used for connecting from the mains to lamps through the subsidiary ducts.

THE STANDARD UNDERGROUND CABLE.—The insulation of the Standard Underground Cable is obtained by first wrapping thick cotton thread or cord around the wire to any desired thickness. The wire thus covered is then placed in a cauldron of boiling insulating compound—a product of petroleum. This treatment displaces any moisture that may be in the cotton thread. After the cotton has been thoroughly saturated with the compound the whole is then lead covered. Care is of course taken by soldering up the ends of the cable to prevent absorption of moisture in shipment and in drawing into the ducts.

There are now in actual service for electric lighting purposes in the New York subways over 95 miles of this cable, carrying currents of an E. M. F. of from 300 to 3,000 volts, including many 1,000-volt alternating circuits, and an additional 50 miles of the same cable will shortly be in operation. The thickness of insulation used in these cables is 5-32, 6-32 and 7-32 of an inch. This refers to the thickness of the insulation from any given point of the circumference of the conductor.

THE "SAFETY" CABLE.—The insulating material of the "Safety" cable is an india-rubber compound. It differs somewhat, I believe, from the ordinary run of india-rubber compound cables in that the compound is placed over the wire, without seams or laps of any kind. This compound is vulcanized to a moderate degree of hardness sufficient to prevent decentering of the heavy conductors which it insulates, but yet it retains a high degree of flexibility.

The thickness of insulation used in No. 4 Brown & Sharpe wire—.204 inch diameter—is .108 inch. The weight of this conductor, lead covered, is 4,861 pounds per mile. Of this the wire weighs 665 pounds, the insulation 669 pounds, the tape 95 pounds, the lead covering 3,432 pounds.

A special thickness of this insulation was made in one instance in response to a call for cable to withstand a strain of 7,000 volts for arc lighting. A sample of this cable is on the table—the thickness of the insulation is .238 inches. The conductor is No. 4 B. & S. gauge. This cable is now in the subways. Its length is about three miles. I am not aware that it has yet been called upon to withstand the prescribed 7,000 volts.

There are now over 65 miles of the "Safety" cable in actual use in the subways, assigned to electric light circuits carrying continuous and alternating currents of from 1,000 to 2,500 volts E. M. F., and about 15 miles additional are now being placed in subways.

THE BISHOP RUBBER COMPOUND CABLE.—The Bishop Rubber Compound Cable is of the well-known Silvertown type, having first a coat of rubber without sulphur, then a coat of rubber compound with sulphur, and over this a lapping of rubber cable, which is then taped. There are two sizes of this cable in the subways; namely: No. 4, B. & S., and No. 6, B. & S. The thickness of the insulation is 4-32 inch; the thickness of the lead covering is 5-64 of an inch; the outside diameter of the cable is .65 of an inch, and the weight of the cable is about 3,432 pounds per mile. There are of this cable, in successful operation, about 10 miles assigned to alternating currents of 1,000 volts, and five miles to arc circuits of 2,500 to 3,000 volts E. M. F. Double this amount of this cable will soon be laid for similar purposes.

THE COBB VULCANITE-PARAFFINE CABLE is of a somewhat unique construction and design. It also differs materially in one respect from the other cables described, in that the conductor is freely movable within its insulating medium. The cable is made in practically the following manner: A vulcanite tube is first made in lengths of about 300 feet. This tube is moderately flexible. The tubing is vulcanized in boiling paraffine. The wire is then threaded through the tube, after which the sections of tubing are jointed together. A thick cord is then wound spirally around the vulcanite tube. The whole is then lead covered, and the space between the vulcanite and lead formed by the spirally wound cord is filled with paraffine.

There are about twenty-five miles of this cable in the subways.

In the case of the Bishop, Safety, Cobb and Patterson cables, the lead is alloyed with about 3 per cent. of tin. The lead covering of the Standard Underground cable is unalloyed, but it is covered with a thick cotton braiding soaked in "P & B" paint (the latter a product of petroleum), which, it is claimed, will protect the lead from acid gases, etc., and the braid also acts to protect the lead from mechanical injury.

Condition of the Cables.

I may say that all of these cables are guaranteed by the manufacturers for three years. This term, however, is not to be taken as signifying the limit placed upon the life of the cables by the manufacturers.

It is over a year since current was turned on the first high tension electric light circuit in the New York subways. This was a circuit in One Hundred and Twenty-fifth street, belonging to the Harlem Electric Light Company. The insulation resistance of the cable, as measured just before the turning on of the current, showed it to be 1750 megohms per mile. A test made of the same circuit last week, after one year's continuous service showed it to have an insu-

lation resistance of 1516 megohms per mile. Since the installation of the circuit just referred to, electric light cables of the various types described have been drawn into the subways almost as rapidly as they could be manufactured, and test made of the conductors months after the initial test has shown them to be in the same electrical condition as when first laid.

There have been several burn-outs in cables in the subways within the year, but with the exception of an abandoned type of cable, to which I shall refer later, these burn-outs have been traceable in every case to defective joints or to mechanical injury. In all, according to the records and best obtainable information, there have been, exclusive of those in the abandoned cable, but five burn-outs in over 185 miles of electric light wire during a period of active service of the conductors ranging from one month to thirteen months.

In the case of 27 out of 34 of the electric light circuits in the subways, not a single defect of any kind has occurred since they were placed in the ducts. There have been several instances where faults not amounting to burn-outs have been discovered by the regular tests which have brought the insulation resistance of certain conductors below the requirements of the rules of the subway, but these defects have generally been located and removed without serious delay to the circuits. Where this has not been the case, it can be fairly attributed to the employment of untried insulation, unfamiliarity with underground service, or to the inexperience of the men to whom the work of connecting up circuits, etc., has been intrusted. For instance, in a number of cases grounds have been traced to contact of the conductor with the lead covering and the linemen so connecting them have explained that they were not aware the lead covering would cause a ground.

On several occasions grounds have been caused by the driving of nails through the lead covering of the cables or leading in wires, under the molding inside of buildings, and on another occasion a ground was caused by a laborer's pick-ax while excavating for a new subway which crossed an existing subway. It is related of the laborer that when he saw the smoke arising from the burning insulation he first tried to put out the fire by throwing water over the cable and subsequently by throwing wet mortar around it.

It is perhaps not remarkable, in view of all the circumstances, that anything in the shape of an electric wire is looked upon by outsiders with serious apprehensions. It has sometimes been amusing to notice the wide berth given even the leading-in wires used during the making of tests of cables by the occupants of buildings from which the test is being made.

On one occasion, while a test was being made in the basement of the Hotel Brunswick, it happened that the lead wires were lying on the floor near by a small pool of water in a hallway. A servant, seeing the water and the wires in close proximity, called out in

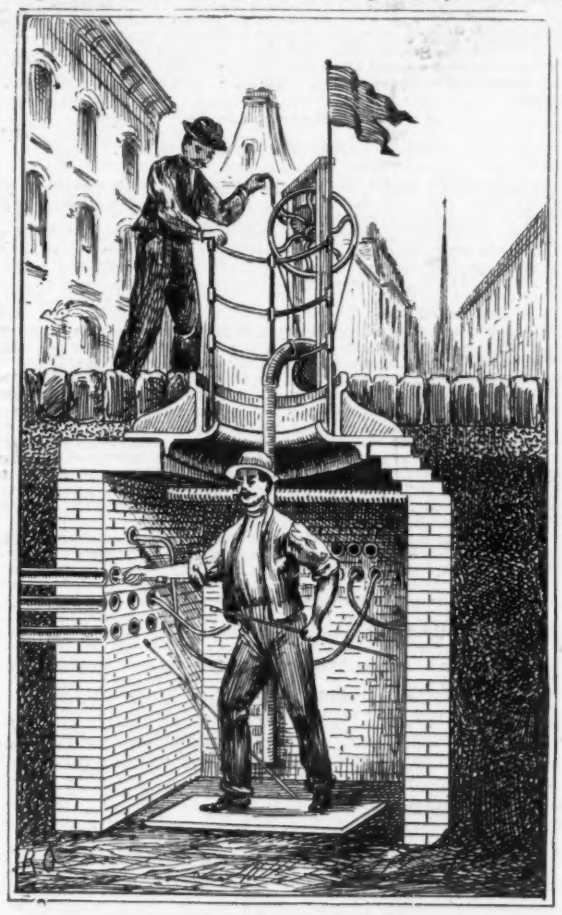


FIG. 3.—DETAILS OF WORKING IN THE NEW YORK SUBWAYS.

alarm to one of her companions who was approaching: "Take care Mary, the electricity is running out."

Defective Cables.

In the case of the cable previously referred to as having been abandoned, the burn-outs were of almost nightly occurrence The delays to the company using this cable were necessarily vexatious, and I may say that in my references to burn-outs, defects, etc., occurring in underground cables, I have not included those that were due to the use of this seemingly inherently defective cable. This was a lead-covered cable with a vulcanite tube as an insulating medium. This special cable has, I believe, been abandoned, and is no longer in service in the New York subways. What may appear a singular feature in connection with the burn-outs in this cable was the fact that the cable had a higher apparent insulation resistance than any other cable in the subways, and would frequently, on a test, show an insulation resistance of over 4,000 megohms per mile a few hours before the occurrence of a burn-out. The same cable showed even a higher test at the factory, namely, about 20,000 megohms per mile. In the latter case it was tested with 400 volts. Burn-outs on this cable have occurred when the pressure employed on the circuit did not exceed 600 volts.

The explanation of this may be that owing to the nature of the insulating material and to the fact that it was not tested under water before being lead covered, there may have existed fractures in the vulcanite tubing, or such fractures may have been caused in process of drawing the cable into the ducts. Under the tests made with the 100 and 400 volts E. M. F. of the testing battery, a fault would not develop; under the high electromotive force of the dynamo and the current of 10 or 12 ampères, the fault would develop, perhaps due to moisture of condensation of the air in the tubes caused by the heating of the wire. This explanation is apparently confirmed by the fact that 25 miles of a somewhat similar cable, namely, the Cobb cable, which I have described, but in which paraffine is placed between the lead covering and the vulcanite tube, has been in successful operation in the subways for high-tension currents for over two months without any indication of a defect having occurred.

It was rather unfortunate that the cable which I have said has been abandoned as unsatisfactory, and which has indeed been withdrawn from the subways, appears to have been the only cable used for electric lighting purposes in the New York subways which came to the notice of an English electrical engineer during a flying visit to this country, and a description of which cable he presented to our sister society in London in a recent paper, with a favorable prediction as to its probable success.

Locating Faults.

The method employed for locating faults in electric light conductors in the subways is to test the conductor from point to point until the defect is placed between two lamps or manholes. When a fault is located between two lamps or two manholes, if it is in the cable proper and not in a joint at a hand hole or box, the defective section is withdrawn, and a perfect section put in its place. With the exception of the hard rubber cable referred to, this has, I believe, been necessary but on three occasions after the current has been turned on the circuit; in two of these the defects were caused by improperly made joints. In the other case by a mechanical injury.

In the case of arc light or series circuits, defects in the cables are more readily located than in multiple arc circuits, because of the facility afforded by the openings at the lamps for testing the conductor in sections. In the case of multiple arc circuits there is at present no means of locating faults but by cutting the conductor in manholes. For, as the house connections are made from the cable by T joints, it is obvious that the only effect of disconnecting the lamps or converters from the cable is to separate the two conductors of the circuit. These remarks, it is understood, do not apply to the Edison conductors, to which it is well known access is had at the ends of each pipe by removing the paving and earth above the pipe.

No attempt is made to locate faults in electric light circuits in the subways by electrical measurements, for the reason that the obstacles in the way of obtaining accurate data are so numerous that it has not been considered expedient to rely on the results of such measurements. For instance, the uncertainty as to the distribution of the resistance of the conductor owing to the numerous joints in the circuit, the variations in temperature of the subways and the difficulty in ascertaining it, etc.

To facilitate the locating of faults, should they occur in the subways, several forms of accessible joints have been suggested for use in the manholes. One of these, known, I think, as the Dillon joint, consists of a metal cup, having in its bottom apertures through which the cable ends pass. The lead covering of the cable is soldered into the cup, the conductors are connected or spliced, and insulated, upon a water-tight cover is screwed over the cup.

Another accessible joint, known as the Cobb joint, is made as follows: A copper disc is soldered on the ends of the conductors to be connected. Over the discs a vulcanite sleeve is placed. Two shoulders having respectively a right and left hand screw are placed, near the sleeve, over the insulation of the conductor. The sleeve is provided with a right and left hand thread. The forward movement of the shoulders is checked by discs on the ends of the conductors. Thus when the sleeve is screwed on to both shoulders the tendency is to press the two discs together tightly. This joint can be made quickly, but as to its practical utility it is not possible to speak definitely as yet, since it has not been in actual service in the subways so far as I am aware. The same is true of the Dillon joint.

It is perhaps a debatable question whether easily accessible joints are desirable in the manholes of subways, as the tendency in such cases might be to lead to accidents by the exposure of live wires.

Durability of Cables.

Concerning the much discussed question as to the relative durability of rubber compound and fibrous cables, I do not think sufficient time has elapsed in the case of the cables in the New York subways to enable one to arrive at a definite judgment. In the case of both types of cable, as I have already said, many circuits have been running continuously for over nine months, and in some instances for over one year, without a defect of any kind, electrical or mechanical, having occurred, and the slighter defects that have occurred on other circuits have as yet been so few in either type of cable as not to certainly show any marked superiority of one type over another. Specimens of cable that have been examined after nine to twelve months service show no physical or electrical signs of deterioration of the insulation.

As regards the question as to which kind of cable will best withstand the heat from steam pipes adjacent to the subways, it would appear thus far that the lead-covered fibrous cable is superior to the homogeneous cable not lead covered. Lead-covered rubber compound cables have not as yet been tried in the heated districts.

Multiple Cables.

There are no concentric cables in the subway in this city. The mains of multiple arc circuits are operated in separate lead covers in the same duct. It is contemplated, I believe, by some of the companies to use one lead cover for such circuits hereafter. One objection on the part of the companies to the use of concentric cables is the anticipated difficulty in making joints, especially where frequent connections for distribution are required. This objection should not hold good in the case of the feeder portion of the circuits.

As to the use of multiple cables for electric lighting, one such cable, a fibrous cable having eight conductors under one-lead cover, was placed in the subways, but has not been operated as yet, trouble having been found in making perfect joints. I have no doubt that with the experience since had in joint making, this difficulty would be overcome, but it seems to be the general opinion that the use of multiple cables is not advisable in electric lighting.

On the subject of loss due to increased electro static capacity or to increased self-induction of conductors in the subways I may say that I have made careful inquiry of superintendents of stations where the alternating current is used and learn that no perceptible difference in the operation of the circuits as compared with similar circuits overhead is noticeable. I have been informed that in wet, stormy weather a decided improvement is observable—in fact that the condition of the weather does not affect the circuit. This will be the more readily understood when it is stated that a recent test made during the prevalence of a drenching rain storm, of an arc circuit in the subways four miles in length, showed an insulation resistance of 2,400 megohms per mile. The lamp connections were disconnected from the cable proper during the tests, so that all the terminals of the entire cable were under cover except at the pole.

Joints.

When it was urged upon the electric light companies of this city that they were not using due diligence in placing their wires underground, the companies retorted that they were doing so as rapidly as possible consistent with good workmanship, and they cited the fact that it was not possible to joint up the cables more rapidly than was being done with the number of capable jointers at their command. To this an official of the city replied that this did not, in his opinion, constitute a valid excuse while so many poor men were idle who would be only too glad to be given work at jointing the cables.

This was the view of a layman, but it would seem that in a number of instances in the electric light service in this country a similar view, namely, that any one could make joints and that any kind of joints might be made, was held by those who should be supposed to know to the contrary.

In this city I think it is now fully recognized, by the electric light companies at least, that it pays to employ good jointers in underground work.

Several forms of joints are used on the electric light cables in subways, among them one known as the rubber joint. It is sometimes termed the half marine joint This joint is made practically as follows: First the lead covering is removed for about 3 inches from the end of the conductor; about one inch of the insulation is then removed from the ends of the conductor; the ends of the conductor are then "sweated" together, generally a split copper sleeve being placed over the ends. When a T joint is to be made a T sleeve is used. This facilitates the making of the joint by dispensing with filing the ends of the conductor, and then wrapping them with small wire. No acid is used in the making of the joint. Resin is commonly used a slag. After the wire has been spliced the insulation is then scarfed for about three-quarters of an inch, when a layer of pure rubber strip is wrapped around the wire spirally, back and forth, about three times, and each time the rubber is brought further up the scarfed insulation. A few layers of white rubber strip is then wound above the pure rubber strip, and after that a layer or two of pink rubber strip. A layer of fibrous rubber tape is then put on over all. Between each layer of rubber strip a small quantity of rubber solution is put on to make the rubber adhesive and practically homogeneous. A lead sleeve is then placed over the joint and wiped on to the lead covering. This joint can be made in about 20 minutes, exclusive of time taken in wiping the lead sleeve. This joint is used altogether on the "Bishop" and the Safety cables; also occasionally on the Standard and Cobb cables. But as a rule the Cobb people make a special joint somewhat as follows: The ends of the conductors are spliced in the usual way, a hard rubber ferrule having first been placed over one end of the conductor and a brass ferrule over the other conductor above the insulation. A machine like a double vise is then placed over the lead covering of the cable and made fast thereto. A tightening device next draws the ends of the vulcanite together, taking up slack in the cable. The vulcanite sleeve or ferrule is then welded by heat to the vulcanite tube, after which the brass ferrule is drawn over the tube. A mold is then placed around the joint into which molten lead is poured, thus casting a solid lead sleeve. This is quickly cooled by the application to the mold of cold water. The mold is then removed and the joint is complete. This form of joint has been found satisfactory, I believe, and it is claimed that it can be made in much less time than a half marine joint.

The joint chiefly used on the Standard Underground Cable is made differently from either of the foregoing. After the conductor has been spliced as usual, and the lead covering has been cut back from the insulation, a few turns of tape is passed around the splice. A leaden sleeve is then put on over this, and wiped firmly to the lead cover of the cable. When this has been done a couple of small holes are punctured in the lead sleeve through which a boiling insulating compound used in the manufacture of the cable is poured, filling up the sleeve completely. After which the holes are closed by solder. These joints have been found to give excellent service in this form of cable. The time taken in making this joint is about 30 minutes.

Lead Covered Cable.

The cables used in the electric light service in the New York subways are as I have elsewhere stated, without exception, lead covered. In the case of fibrous insulation, this is essential to exclude moisture, but not in the case of the rubber cables except as a protection against gas and acids and to a certain extent, mechanical injury. The use of this lead covering is not required by the subway rules. In addition to being a protection against the attack of acids and gases, the lead covering is considered a safeguard against accidents to men working in the manholes among live wires. For in the first place, if a defect should occur in the insulation in the manhole, the presence of a ground furnished by the lead covering would make the defect known at the regular test, which, if the defect were of a serious nature would insure its being located and eliminated Whereas, if the conductor were not lead covered there is a probability that a defect in the insulation might occur that would not be indicated by the test, but which might expose the conductor and render it possible for workmen in the manholes to make contact therewith. It would be quite possible for a workman to handle the lead covering of even a defective conductor without injury since the lead covering is grounded throughout the length of the subway.

It will hardly be credited by some people, but it is a fact that live electric light wires conveying the alternating high tension arc currents are handled and moved about in the manholes by means of the lead covering without the slightest indication that such wires are alive. In fact, it is quite a common occurrence to start up alternating circuits immediately after a rubber joint has been made in order to save time and then to have the plumber adjust and wipe the sleeve on to the lead cover while the current is in full operation.

Another fact is this, that in the subways no shocks whatever due to induced currents in the lead covering are felt by the workmen in handling the lead covered cables conveying the alternating current. It is quite conceivable that such shocks might be noticed, as I believe they are, where the cables are suspended from point to point and insulated. In that case any one handling the lead covering of the conductors would doubtless receive the accumulated induced charge

It has been stated frequently that such induced currents, where the lead covering of the conductors is insulated, have been known to injure the lead covering and eventually to destroy the insulation.

So far as I have been able to ascertain, not in a single instance has such an action taken place in the subways.

As a matter of fact close personal observation and careful inquiry on all sides have failed to discover thus far any sign of deterioration in the condition of the material of the conduits, the lead covering of the insulation, or of the insulation of the cables in the subways, with the exception of the effect upon the lead covering

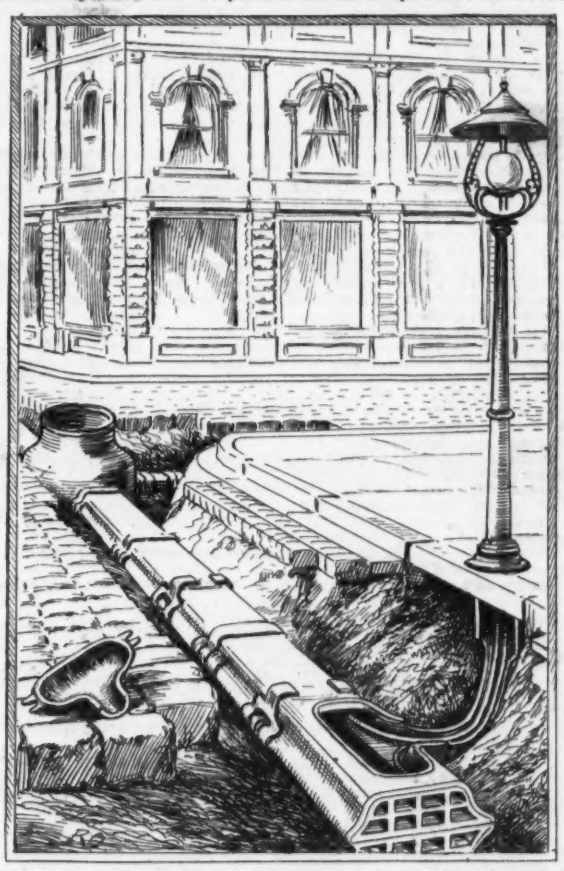


FIG. 4.—DETAILS OF WORKING IN THE NEW YORK SUBWAYS.

of the telephone cable in the creosoted wood conduit referred to. I may add that even in the latter case, personal investigation and inquiry made of workmen have not confirmed the statement that the lead covering has been attacked. At all events there is no evidence of any such wholesale manufacture of white lead as has been reported from other places where lead covered cables have been placed in creosoted wood boxes.

Insulation and Tests.

The requirements of the rules of the subway company, as regards insulation, are such that none but a first-class insulation can well be employed on the conductors conveying currents of high electromotive force. These rules require an initial insulation resistance of 15 megohms per mile per 100 volts electromotive force employed on the circuit, and a minimum of five megohms per mile per 100 volts. The initial test is made when the conductor is first laid in the subway, and prior to the turning on of the current. The minimum requirement is allowed after the circuit has been in use. This insulation requirement refers to the conductor proper in the subway, and does not include the lamps, aerial connections or converters. The rule does not apply to conductors conveying currents of less than 100 volts E. M. F. In the case of alternating circuits, the uniform electromotive force employed in this city being 1,000 volts, the conductors to be employed in this service are required to show an initial insulation resistance of 150 megohms per mile, and a minimum insulation resistance afterwards of at least 50 megohms per mile.

The average E. M. F. of the arc light circuits in the subways is about 2,000 volts, but in some instances it runs up to 3,500 volts. In the latter case the initial insulation resistance required by the rules is 525 megohms per mile; minimum, 175 megohms per mile.

It was at first thought by many that it would be impossible to maintain even the minimum insulation resistance required by the rules, and this supposed impossibility was cited by some of the electric light companies as an instance of the impracticability of the proposition that they should utilize the subways. The representative of one such company very naively stated that it would certainly be impossible for his company to maintain this insulation if compelled to go into the subways, as the insulation his company used in its service was underwriters'. One of the experts of the same company, in his evidence, repeated the very common remark that one megohm, *if it could be maintained*, would be quite sufficient for practical purposes. I do not think this statement will be seriously contradicted, but the difficulty is to maintain the insulation resistance at one megohm in practice. Experience in the New York subways has shown that it is vastly easier to maintain the insulation resistance at 150, and even 500 megohms per mile than it has been in the past in other cities to maintain them at one megohm per mile. A gentlemen writing of the Chicago underground system, not quite two years ago, remarked: "It was found that although the insulation measurement of the lead covered cables in the conduit was very high, considerably above a megohm, a short circuit would form generally within 1,000 feet of the station between the two sides of the circuit."

The explanation for this short circuiting under such conditions would appear to be simple, namely, that if the insulation resistance of a conductor is but one megohm per mile, the covering

being of the ordinary thickness, it is clear enough that it is decidedly inferior insulation, and if the normal insulation resistance of the conductor is very much higher than one megohm per mile; but the measurement nevertheless shows it to have an insulation resistance of but one megohm, it is or should be sufficient evidence that a fault has developed in the insulation which need surprise no one when it produces a short circuit or burn-out.

As I was in no wise responsible for the promulgation of the sub way rule which places the initial and minimum insulation resistance of the electric light conductors at the figures given, not having been connected with the company in any capacity at the time the rule was authorized, modesty need not restrain me from saying that experience of over a year has amply proven the wisdom of those requirements. For these requirements not only necessitated the use of an insulating material possessing high specific insulation, but also compelled the exercise of the greatest care in the details of placing the conductors in the conduits, in the making of joints, etc.

When it is stated that these conductors are jointed at every manhole, and in many instances at several places between manholes, the need of such carefulness in order to maintain a high insulation will be understood.

If, for example, the method of making joints that it is related was employed some years ago in Philadelphia—namely, to strip the ends of the lead covering for two or three inches and then to place three or four turns of tape around the ends of the conductor—had been followed in the New York subways, and had been permitted in the absence of the rules referred to, I make no doubt I would have had to report to-night a continued series of failures in the electric light service similar to those so often quoted as having happened in Philadelphia. I am confirmed in this belief by the fact that the first electric light conductors laid in the New York subways were found to possess an insulation resistance of but little over 100,000 ohms. This, notwithstanding that the insulation resistance of the conductors at the factory was over 2,000 megohms per mile. There were about 40 joints in these conductors. Where these had been cut out and new ones made by an expert jointer the insulation resistance rose to over 1,500 megohms per mile, and a very recent test of the same circuit shows it to possess virtually the same insulation resistance.

Under the methods once in vogue in other cities in this country with regard to underground work, in which no tests for defects were made excepting for such as would be indicated by an ordinary magneto, the circuit I have referred to would have been put in operation without question, and there is, I think, not much doubt as to what the outcome would have been.

The high tension electric light conductors are tested weekly for insulation resistance. The tests are made by the direct deflection method, a Thomson reflecting galvanometer being used, and as a rule a 100-cell chloride of silver battery is employed as a testing battery. The tests are generally made from some room or basement adjacent to the terminals of the conductors in the subway, in order that the subway portion of the circuit may be tested exclusive of aerial portions.

At present the subways do not extend to the electric light stations, although in a very short time they will do so in the case of the Stanton Street United States Illuminating Company's station.

When the conductors emerge from the subways they are run through subsidiary iron pipes up the side of a pole. From this pole the testing lead wires are run to the testing room.

The subway conductors are as a rule tested exclusive of arc lamps, converter and inside wiring, but frequently also the tests are made inclusive of arc lamps and converters. These latter tests are only accepted when the results fairly indicate that the fault of insulation is due to the lamps or converters. In quite a number of cases the tests with converters included show an insulation resistance up to the requirements.

Tests of circuits are not made inclusive of house wiring, because of the generally low results of trial test. Some such tests that I have made showed an insulation resistance of the house wiring of less than 1,000 ohms.

The following record of actual tests may be of interest:

Circuit A, Arc. Initial test 588 meghoms per mile. Last test of same circuit 388 megohms. Present length of circuit 9.5 miles.

Circuit B, alternating. Initial test 141 megohms. Last test 1,250 meghoms. Length 9.6 miles. The first test was made when circuit was much shorter than at present, and doubtless, the terminals of conductor were exposed during that test.

Circuit D. Initial test, Jan. 6, 1889, 424 megohms per mile. Length of circuit two miles. Subsequent test, Jan. 2, 1890, 484 meghoms per mile.

Circuit E. Jan. 4, 1889. 1,750 megohms per mile. Same circuit, Jan. 4, 1890, 1,516 megohms per mile. Length, 1 mile.

Circuit F. July 7, 1889, 264 megohms per mile. Jan. 3, 1890, 343 megohms. Length, 6.6 miles.

The readings for these tests are generally taken after one or two minutes' electrification.

Tests with converters included in some cases show very fair insulations. One circuit with 34 converters included showed 11 megohms total insulation resistance. Another with 11 converters included gave a total insulation resistance of 159 megohms. It is not uncommon to get an insulation resistance of from two to five megohms with 30 and 40 converters in circuit. These tests did not include aerial portions of circuits. It should be said that the insulation of the converters and connections is being constantly improved, and, in my opinion, the time is not remote when the underground circuits will test up to requirements at all times with converters included.

As all of the conductors of the same company do not terminate at any one point, and the instruments have to be moved from place to place, the apparatus used in making the tests is of a portable pattern. The entire outfit can in an emergency be carried by one person, and very readily by two persons.

Contrary to the expectations of some people, the actual making of these electrical tests has not been attended with any serious difficulty. The most troublesome factor has been that due to surface leakage at the battery or other parts of the testing equipment, during the very humid weather, which prevailed so continuously last summer and winter.

The time for making these tests is as far as possible chosen to suit the convenience of customers. The majority of the tests are now made in the early mornings. All circuits are tested once a week at least.

About 130 miles of the subway electric light conductors referred to are employed as carriers of alternate current for incandescent lighting. About 60 miles as carriers of arc light, and incandescent continuous currents. The circuits vary in length from one mile to eleven miles; the longest arc light circuit is 10 miles in length—the longest alternating circuit is 11 miles in length. In 10 miles of alternating or arc circuit there are from 450 to 500 joints. The greatest number of converters on one subway circuit is 65. There are 14 arc light circuits and 25 alternating circuits in the subways.

Quite recently an alternating arc circuit has been installed in the subways which is intended to be the pioneer of numerous such circuits. I may say that it is ultimately intended to operate at least 125 arc lamps in such circuits.

Lightning Arresters.

In the case of many of the electric light circuits that were first laid in the subways of New York city, lightning arresters were used at street lamps and at the terminals of the cable, and in a number of instances the same apparatus is still used. These "arresters" are those known as the Acheson cable protector, and are intended to protect the cable against disruptive discharges from any source. The principle upon which the device is intended to act is that the disruptive discharges, or what would be the disruptive discharge, will jump the air space between the points of the needles, thus relieving the cable from the strain. The utility of this device for the purpose intended has yet to be demonstrated in this city, inasmuch as the frequency of burn-outs in unprotected cables in the subways has been no greater than in those which are equipped with the protector, the percentage of burn-outs on cables in either case being, as I have before intimated, very low. It is as yet, I think, an open question whether the use of this or any equivalent device is warranted. There is no record of any of the cables in the New York subways having received injury from lightning during the past year.

It is commonly supposed that the freedom from burn-outs which the successful electric light cables in the New York subways have enjoyed, as compared with the earlier experience of other cities, is due to an increased thickness of insulation around the conductor. This may be the correct explanation, but the fact is worthy of attention in connection with this subject that certain electrical condensers have for years been placed in positions where they are exposed to the full effect of lightning discharges on telegraph lines, without in a single instance having sustained injury therefrom. Similar instruments have also been placed across the poles of 1,000 volts alternating dynamo machines for days without perceptible harmful effect. Since it is difficult to imagine a better opportunity for a disruptive discharge to effect its escape to earth than that presented by the extremely thin tissue paper used in those condensers, the thought is suggested that if this paper can be so constructed as to act as a barrier to the passage of such charges there may be more to be considered in this matter of insulation than the mere question of thickness of the insulating material.

Alleged Dangers of the Subways.

The dangers to be apprehended from the existence of the electrical subways and from the placing of the high-tension wires therein, according to those who are perhaps more or less inimical to that action, are varied. In general terms, they say that the dangers which menace the public and employés from the presence of wires overhead will be multiplied manifold when the wires are underground. But, when asked to specify those dangers, the reply is limited to the following, namely: first, that linemen will be killed by coming in contact with live wires in the manholes; second, that high-tension currents will leave the subways and enter buildings by way of water and gas-pipes, etc.; and, third, that accidents due to explosions of gas in the subways will be numerous.

As regards accidents to workmen in the manholes, due to contact with live wires, no one will say that such occurrences are impossible, but inasmuch as not a single accident of this kind has occurred in New York City, or so far as I can learn, elsewhere, in electrical subways, it is fair to assume that, with the exercise of proper supervision of the wires, this is not likely to prove a frequent source of accident. I was present at the inquest on one of the unfortunate linemen who was killed last year in New York City by contact with an overhead wire, when a witness who had just made the statement that he apprehended more accidents from the placing of wires underground than had occurred overhead, was asked if he was aware that there were at the time about 100 miles of electric light wire underground in New York City conveying high tension currents, and that not one accident had thus far occurred in the manholes; to which he replied that this state of things was explainable in his opinion by the fact that the electric light wires underground constituted but one-tenth of the electric wires of the city, and that when all the wires were underground the accidents in the subways would increase in the same proportion; which reply caused the foreman of the Jury to remark that the public would probably not complain of an increase of accidents from nought to 10 times nought.

I have already suggested in another place that the fact of the wires being metallically covered may have conduced to the immunity from accidents which the workmen in the manholes have enjoyed. I may interpolate here that it is recognized that the efficiency of the manholes would in many instances be increased if they were larger, and wherever the surrounding condition of the street will permit, it is, I believe, contemplated to enlarge the manholes.

So far as the statement is concerned that danger is to be apprehended by the entrance of powerful currents into buildings by way of water and gas pipes, by contact of a grounded conductor in the subways, it would scarcely be worthy of notice before a body of electricians, but for the persistency with which it is said to be urged by men of prominence in the electrical profession. It is conceivable that if a conductor, within a building, should by accident come into contact with a well-insulated gas pipe also within a building, one might receive a shock by contact with the gas pipe if in some manner he should complete the circuit, but in what manner, in the event of a ground in the subways, any dangerous current can be conveyed to the inside of a building by means of gas and water pipes which have the entire area of the city's foundation as a ground or return circuit is more difficult to understand.

But whatever may be the dangers, stated and unstated, so freely predicted as liable to occur with the wires underground, it may certainly be said that with the electric wires underground men will not be injured by falling off poles in the subways. Wires when in the subways during the prevalence of sleet storms, etc., will not fall upon people or horses in the street, nor be torn down by elevated railway trains, street cars, etc.

Gas in the Subways.

In my opinion the presence of gas is the most serious defect of the electrical subways in cities; of course it is not an inherent defect in the subways, but it is nevertheless a very troublesome one, not only because of the danger of explosions therefrom, but also because of its ill effects upon workmen employed in the subways.

As previously remarked, the ducts used in the subways are not only joined together as nearly hermetically as possible, but, except in the case of distributing ducts they are laid in a solid body of cement from manhole to manhole. It is supposed that the gas obtains ingress to the manholes through the place where the iron manhole cover rests upon the masonry of the manhole. But at whatever point the gas enters the subways, its unwelcome presence is acknowledged, and while it is self-evident to any one who will investigate the matter for himself, and is actually admitted by the gas companies that the gas emanates from the gas mains in the streets, nevertheless the subway engineers have been constantly at work devising means to remove the intruder.

To this end various methods for ventilating the subways have been suggested and tried, the most successful of which thus far has been the ventilation of the subways by the use of blowers stationed at intervals along the subways, and arrangements are now in progress to place fifteen such blowers in operation to cover the entire subway system.

As the ducts become filled with cables, however, the free passage of air through them is prevented, and in this way the utility of the blowers is diminished. In order to evade this difficulty a six-inch wrought-iron pipe has been laid above the subway ducts in the more recently constructed subways. This large iron pipe has openings at each manhole. The openings are graduated as to their extent as they recede from the source of the air pressure. The larger openings are at the points remote from the blower. It is intended by the use of these large pipes to furnish a counter-pressure in the subways some what exceeding any tendency of a pressure from the outside—rather than to produce a strong current of air through the ducts, and in this way to prevent the ingress of gas through any crevices that may exist in the subways.

These air pipes are shown in the drawing, Fig. 5, to the right of the distributing ducts.

It has been frequently suggested that good results might follow a suction method of ventilation, but experience has shown that this would rather aggravate the evil, as it would draw into the subway all the accumulated gas in the streets besides inviting a large leakage from the gas mains.

The only beneficial effect to the subways of this resort to blowers to drive out the gas is that the air dries up the ducts and manholes within quite a distance of the blowers.

The cause of these explosions in the subways has not in every case been definitely located. It is of course known that they are due primarily to the ignition of an accumulation of illuminating gas mixed with atmospheric air in the explosive proportions, but the difficulty has been to ascertain by what means the gas has been ignited. It is on record that these explosions have occurred in sections of the subways in which there were at the time no wires whatever. And in cases where there have been live wires in the vicinity of an explosion, tests made immediately after the event have shown that those wires were in practically perfect condition as regards insulation. There are but three instances on record in which a defect in an electric light cable has occurred simultaneously with an explosion in the subways, and in one of these cases the defect occurred so nearly incidentally with the explosion that while it is quite possible that the defect may have caused the explosion, it—the defect—may have been due to mechanical injury due to the explosion.

Among other theories it has been suggested that the gas may be ignited by currents induced in the lead covering of alternating current conductors. This might be the case if, as I have before suggested, the cables were supported from beam to beam, as on a bridge, on insulated stands, and if the lead coverings only approached each other at intervals; but where the lead coverings of the conductors are not only grounded throughout their lengths as in the subways, but are also joined metallically, in fact are practically one cable in the ducts, it seems unlikely that a quantity of induced electricity, sufficient to produce a spark, could be accumulated at any one point.

At all events no sparks are observable in the subways at any time, and as I have already said, there is no evidence of the generation of such charges manifested by the handling of the lead covering of the cables.

In the case of at least two explosions in New York City, the evidence showed that the gas in the subways had been ignited by a lighted lamp or match in the vicinity of some subsidiary duct connecting with the subways. In other instances by a match or lighted cigar thrown in a manhole. It is known that in Chicago an explosion was caused in the subways by a live coal from a passing fire-engine falling upon the cover of a manhole.

With but one or two exceptions the explosions have not injured the cables in the subways, which is probably due to the small and round surface which the cables present.

It has frequently been suggested that if solid ducts were employed instead of tubular ducts these explosions would be avoided. While this would be, if correct, a strong argument in favor of solid conduits, that is, ducts in which the conductors are not removable, notwithstanding the generally admitted fact that such ducts are not practicable for subway work on a large scale, experience has demonstrated that explosions have occurred repeatedly in manholes and in small junction boxes of subway systems in which there were no hollow ducts.

I may add that, pending the installation of blowers in certain of the subways, men are employed day and night opening manholes to permit escape of gas.

I had intended to comment briefly on the comparative expense of maintenance and reliability of underground wires in cities as compared with overhead wires, but as my paper has far exceeded the limits which I had placed upon it, I shall leave that and other features in abeyance for the present. Perhaps something bearing on those points may be brought out in the discussion.

The following are some of the rules of the subways of New York City which have been promulgated as precautionary measures or as a result of actual experience

No bare ends or bare portions of conductors, whether in or out of service, are permitted in the manholes. Every conductor in the manhole is treated as though it were operative.

No joints, except such as are protected by a metallic covering, are permitted in the manholes.

No exposed lights or fires are allowed in manholes.

All conductors in manholes are required to be arranged symmetrically around the walls and to be plainly tagged with the designating mark of circuit and the name of the owner. One of the pictures which I have, by the courtesy of Mr. Beckwith, the Chief Engineer of the Subway Commission, been able to procure from his office, shows the cables passing through the manhole in rather a haphazard way. This would do where there are but one or two conductors in the conduits, but when the conductors multiply, an orderly arrangement of them is essential.

No switch boxes are allowed in the manholes. The reason for this is that, in the first place, a switch box for each company would take up too much of the limited room; and secondly, in the case of electric light circuits, it is feared that attempts to change live circuits might produce dangerous sparks in the manholes.

In conclusion, I think it may be said that the experience derived from the practical operation of the electrical subways of New York City has either made apparent or confirmed, among other things, the following:

That it is possible to successfully operate all classes of electric conductors underground in cities.

That at least for conductors conveying high-tension currents underground it is advisable to set the standard of insulation high.

That regular insulation tests of the conductors are very valuable.

That liberal thickness of insulation is desirable for high-tension currents.

That it is unadvisable to place underground new types of cable or insulation until they have been subjected to tests and conditions analogous to those to which they will be subjected underground.

That for electric light conductors—especially distributing mains—many conductors under one cover are not advisable owing chiefly to the difficulty in making joints in such cables.

That all sharp edges in ducts should be avoided.

That until the gas light companies are required, like the electric light companies, to maintain their mains in a fairly sound condition underground, a means of ventilating the subways should be provided simultaneously with the construction of the subways.

And lastly, that while other features may be accessories thereto, the employment of smooth, strong conduits, accessible ducts for distribution of the current, first-class insulation, constant expert attention to details and thorough organization in every department are essential to the production of a successful electrical underground system.

An Electric Motor in a Play.

An interesting and novel application of electric power has recently been made in New York City by the local agent of the Sprague Electric Railway and Motor Company.

In one of the theatres a spectacular play, Neil Burgess's "County Fair," is being presented, in which one of the features consists of a horserace on the stage. In order to keep the horses constantly in view of the audience, the platform upon which the horses race is endless, and kept constantly moving over a pair of rollers at each end of the stage.

When the question of motive power for this movable stage was suggested, a Sprague stationary motor was selected for the work. This is belted to a system of counter-shafting which reduces the speed to that required by the rollers over which the movable platform revolves. This is rather a novel application of electric power, but it is simply an example of the extensive and varied use to which electric motors are now being applied. When the manufacturers of the Sprague motor made the statement a year or so ago that their motors were used in more than 130 industries, the statement seemed almost incredible, but the convenience of the electric motor, and its wide range of adaptability to all classes of work, have made it almost a necessity in places where no other motor could be used.

We have no doubt that the number of different industries to which Sprague motors have been applied is now very largely in excess of what was stated a year ago.

Patents and Copyrights Discussed at the New York Electric Club.

At the monthly meeting of the New York Electric Club, held on Feb. 20, Mr. H. L. Storke in the chair, Mr. Grosvenor P. Lowrey read a most instructive and amusing paper on patents. The discussion was participated in by Messrs. E. P. Thompson, C. G. Curtis and L. W. Serrell. The following resolution was then introduced by Mr. G. M. Phelps, seconded by Mr. Jos. Wetzler, and carried unanimously:

Resolved, That the Electric Club of New York is in hearty sympathy with the present efforts of American authors, publishers, employing printers and workmen in the printing trades to obtain from Congress a just recognition of the rights of intellectual property, and it hails with satisfaction the prospect of an early passage of the International Copyright Bill.

Mr. R. U. Johnson, of the *Century Magazine*, and secretary of the American Copyright League, in thanking the club for this approval of the league's work, took occasion to outline the history of the international copyright movement and the nature of the measure which is now before Congress and is receiving general support there. Mr. Johnson alluded also to the statement recently made by the Count de Keratry to the effect that were longer delay experienced in securing international copyright protection, the feeling in France would probably lead to a denial there of patent rights to foreigners. Mr. Johnson's interesting speech was heard with much pleasure by the large assemblage. The proceedings closed with a lunch and singing by the Bartlett quartette.

Electric Roads for St. Paul and Minneapolis.

During the last week Mr. Thos. Lowry, president of one of the largest street railway combinations in the world, showed his confidence in the electric system of street railway propulsion by deciding to equip all the lines of St. Paul and Minneapolis by electricity. The electric company to whom this contract was awarded is the Sprague Electric Railway and Motor Company, and the investment called for from the street railway company is said to be in the neighborhood of $2,000,000.

Before deciding upon any system to be used upon these roads, the president of the company, together with the directors, made a careful inspection of all the different methods of operating street cars in large cities, and investigated the merits of each. As a result of this investigation, the contracts for the partial equipment of the road by cable were cancelled, and negotiations were entered into with the Sprague Company for the entire electrical equipment.

By the terms of the contract, the Sprague Company is to fully equip and put into working order the entire mileage owned by the railway company, the work to be completed by June 1st; and the first delivery of electric railway apparatus, which will include 400 Sprague improved motors for the equipment of the rolling stock, will be made shortly.

This is probably the largest order which has ever been given for electric railway motors, and evinces the con-

fidence which prominent street railway managers feel in the electric system.

Control of the New Lighting Subways in New York City.

An eventful point in the history of the underground conduits of New York City is about to be determined, to wit, Whether or not the Board of Electrical Control has or has not the right to award a contract for the construction of subways to the Standard Electrical Subway Company. This point has been brought to an issue by the two long and stormy meetings of the Board on the 17th and 19th ult.

The former meeting was opened by a statement by the Corporation Counsel that he had, after careful consideration of the question referred to him at the previous meeting, decided that the board had a right to make a contract with the Standard Company, which is represented by Wheeler H. Peckham, for the construction of underground conduits.

Ex-Senator GRADY, who appeared for the East River Company, contended that the Board had no power to make any further contract unless the Consolidated Subway Company had by some act or some omission put itself in the position of having committed a breach of contract. He protested that no opportunity had been afforded to the electric light companies to examine the proposed contract, and the company he represented had not understood that any such question was before the Corporation Counsel. The possession of the control of the subways by a corporation which might be closely associated with interests rival to those which he represented would, undoubtedly, imperil seriously the conduct of the business, if not the actual existence of the East River Company. He protested against the establishment of such a monopoly, which would place all the small electric light companies at a disadvantage, and he asked if the East River Company could not be allowed to build its own subways.

Mr. ELIHU ROOT, who appeared for the Manhattan Company, said he had already submitted to the Corporation Counsel certain reasons which he had for believing that the Board could not make such a contract as was proposed, but as the Corporation Counsel had advised the Board differently he would place before the meeting the grounds of the conviction by which he was possessed. Mr. Root continued: "We are forced to place our conductors underground, and you are forced, not only by the express provisions of the statute, but by the responsibility that rests upon you as public officers, to see to it that you do not enforce that provision in such a way as to give any unfair advantage to any particular competitor. Now, I submit that the proposed contract will, if it be made with the company that now asks for it, absolutely destroy the equality of conditions to which we are entitled when we obey the act of the Legislature and your injunctions in placing our wires underground. In the first place the Standard Electrical Subway Company is a company which, I am advised, and as my clients direct me to say they are prepared to prove, is but another name for the strongest and most powerful rival corporation with which we have to do. If you make a contract with the Standard Electrical Subway Company under which they can construct the subways in which we are compelled to put our wires, you are making a contract with our most dangerous competitor, and placing us completely at its mercy."

Mr. ROOT went on to say that the Standard Company was simply the Westinghouse Company in another form, being part of the United Electric Light and Power Company, which controls the combined rights of the Westinghouse, the United States and the Brush companies in New York City. He showed that the capital stock of the Standard Company will be $1,500,000, of which $1,000,000 will be common stock and $500,000 preferred stock.

The $1,000,000 of common stock will be issued for rights, etc., to the United Electric Light and Power Company or some trustee representing it. The United Company will subscribe for the $500,000 of preferred stock at par for the purpose of providing funds to make the cash payments to the Consolidated Telegraph and Electrical Subway Company required by the terms of the purchase. The Standard Company will also at once authorize a mortgage of $3,000,000 to secure that amount of bonds as they may be required.

In commenting on these proposed financial operations, Mr. Root said the Board would have done better to make a contract with the Westinghouse Company itself. "The effect of this proposed contract will be to create a gigantic monopoly to own these subways, which are to be administered by you for the equal use of all the persons furnishing electric light and power in this city, for all the people in the city, and to control those subways in their own interest." One of the specific effects of this would be, said Mr. Root, that "the rental charged for the use of the subways by this sham Standard Company, this shadow and image of a company, that is set up here to stand between our rival and us, will be excessive, and we cannot prevent it. If such a contract is to be made at all it should not be made until the rules of the Board of Electric Control are so changed as to afford fair and proper protection to companies other than those interested in the scheme."

"Why not adopt the policy which is followed with respect to railroads and their franchises, put up a fair contract and give the electric light companies of the city an opportunity to bid for the right? Why should not the other electric lighting companies of the city have equal advantages and an equal right for the competition of this contract with the company which now seeks to secure it?"

Mr. DELANCEY NICOLL, in the interest of the Thomson-Houston and the Northern New York Companies, entered a protest against the proposed contract, which, he said, would wipe some of the companies out of existence. What were safe rules when Mr. Lauterbach's company had control of the subways would not be safe rules when they came to be administered by a rival company, and while he admitted the urgent necessity of increasing the facilities for rapidly pushing on the building of additional subways, he insisted that the Board should dominate the rules, routes and rentals of any new contract, and that it should be of such a nature as to give the companies he represented a living chance with the rest.

The MAYOR: "So long as I am on this Board, Mr. Nicoll, that shall be done."

Mr. Gilroy here stated that unless the Board decided on some definite action during the meeting then in progress, he should be compelled to go on with the paving of the streets, as he could wait no longer.

Mr. HESS: "Have your companies ever found fault with the rules as they now exist, Mr. Nicoll?"

Mr. NICOLL: "No, and never would so long as Mr. Lauterbach controlled matters."

Mr. NICOLL asked that the matter be adjourned for a week, which could not be regarded as an unreasonable time under the circumstances.

The MAYOR: "If it were not for Mr. Gilroy, I would give you all the time possible, but Mr. Gilroy wants to finish the pavement."

Ex-Senator GRADY deprecated the haste with which the Mayor proposed to have the contract closed. He said his company had been hitherto in ignorance as to the fact that such a contract was in progress, and before it was concluded surely the East River Company, which would be so vitally effected by it, should have some voice in the rules under which the new "deal" was to be conducted. "The Mayor said: 'Let us close the contract, and if there is anything you don't like in the rules you can come to us afterward and we will consider it.'" His (Senator Grady's) position was that the rules should be made square and fair before the contract was made, and his company should have an opportunity of scrutinizing them, and if necessary making suggestions for their improvement. "This delay will do more than give time for a proper scrutiny of the proposed rules. It will keep from your administration, Mr. Mayor, a whisper of any failure to observe the rights of all the interests of the city. This is of vastly more importance than the paving of the streets or the burying of the wires, and a week's delay matters very little compared with the protection it gives the interests most benefitted by that contract."

After Mr. Peckham had spoken in favor of the proposed contract, and protested that to talk of his company as a sham was all nonsense, as it had millions of dollars at its back, and had unique facilities for carrying on the work it had in view, the Board passed the following resolution:

RESOLVED, That the Board enter into a contract with the Standard Electrical Subway Company for the construction of subways for electric light and power conduits in such streets and avenues in the City of New York as the Board may direct, and that the settlement of the terms and conditions of said contract be had at a meeting of this Board to be held on Feb. 19, 1890, at 12 o'clock, in the City Hall; each electric light and power company to submit, in the meantime, its proposed amendments to the form of the existing contract.

On the 19th a large number of electric light men and lawyers assembled in the Mayor's office. On the Mayor stating that he had received only one objection to the contract, viz., from the North New York Electric Light Company, ex-Senator Grady rose to say that the East River Company joined in the protest.

The Mayor was about to consider the amendments which had been suggested by the various companies, when Elihu Root appeared and served an injunction restraining the Mayor and the Board of Electrical Control from modifying the existing contract with the Consolidated Telegraph and Electrical Subway Company, and from making any new contract with the Standard Company. It also restrains the transfer of the subways by the Consolidated Company to the Standard Company. The injunction was returnable on Feb. 26. This effectually impeded the progress of the business in hand, and when the Board adjourned it was hoped that the injunction would be argued on Friday, so that the Board could meet on the afternoon of that day to close the contract, if the result of the argument was favorable to their doing so. Judge Barret, however, decided on Friday morning that he could take no action in the matter of the injunction, as he was sitting only temporarily in chambers.

The Dynamo Plant of the Western Union Company, Chicago.

Owing to the absorption of the competing lines, the extension of old circuits and the rapid construction of new ones, the officials of the Western Union Telegraph Company have long seen the necessity for the establishment in Chicago of a dynamo electric plant affording currents of low potential for use in operating both their main and local circuits, as their battery plant had increased in proportion so rapidly that its proper storing and maintenance became a matter of serious importance as well as heavy expense. Until the fall of 1889, however, no convenient rooms or building could be secured for the proper and permanent erection of the plant, when the three-story and basement brick building at 171 Calhoun Place was leased, and Mr. L. L. Summers was directed to prepare plans and specifications covering the complete installation. The plans submitted were approved, and the entire work was then carried through under the personal supervision of Mr. Summers, who strengthened the building, as well as modified and repaired the various rooms in accordance with the plans, securing a clear floor space of 18 × 57 feet on each floor, and erected three strong oak platforms one foot in height, running the entire length of one side and one-half the length of the opposite side on the ground floor. On these were placed the generating machines, consisting of 19 Edison dynamos, two of the platforms holding seven dynamos each, and one platform five. Of these 19 dynamos four are machines specially wound and designed for use in operating the "locals" about the office and the loop circuits connecting in the branch offices. The two dynamos used on the local circuits are wound for a current of 10 volts and 125 ampères, but for the present will only be driven at a speed yielding 7 volts. The two dynamos used on the loops are proportioned for a current of 30 volts and 75 ampères, but will be revolved to give 20 volts. One of each of the above machine will be held as a reserve force.

The remaining 15 dynamos will be used for main line work and are the regular Edison No. 2 type of generators, wound for 40 ampères and 125 volts when driven at a speed of 1,800 revolutions, but will be operated at a speed of 1,200 revolutions, thus giving 70 volts each or a maximum potential of 350 volts for the line, a "tap" from each dynamo being carried to the main circuit. One set of five dynamos is arranged to furnish the positive current, while a second set supplies the negative, the third set of five being held in reserve to furnish either current, should occasion or accident require. The changing from one set to the other is done without any interruption by placing the two sets of dynamos in multiple, the switch employed for this purpose being a model of compactness and convenience and a modification of the one in use in the New York office.

Special okonite cables are used, and the drop in potential between operating and dynamo room is only one volt.

All the dynamos are connected by Munson leather belting to one or two lines of shafting suspended from the ceiling, the shafting being belted to the pulleys of three special cumulative wound Sprague motors, two of 15 h. p. and one of 10 h. p., respectively, and each fitted with a special resistance box arranged as a shunt to the differential and cumulative series coils of the motor, the effect being to compensate for the increase in speed due to the heating of the fields of the motor.

Incandescent lamps are used for supplying the necessary resistance in the main line circuits, and all sounders and locals are wound to give a resistance of 50 ohms, replacing the ordinary four-ohm instruments formerly in service, and are now connected across the leads without any extra resistance being placed in circuit with them. Each table is guarded by a Plush protector, and each branch lead by a fusible plug. Formerly, when worked with battery current, $\frac{1}{10}$ to $\frac{1}{15}$ ampères were required in the operation of each instrument of four ohms resistance, while with the 50-ohm sounders worked on a current strength of $\frac{1}{14}$ ampère and five volts potential, a better "local" is secured in every way.

This plant, as designed by Mr. L. L. Summers, is said to be the most complete of its kind in this country and probably in the world, being the third plant on record furnishing current from dynamos to loop and local as well as main circuits. The Pittsburgh office operate their main lines and a short loop system from their local machine. A description of this latter plant may be found on page 195 of THE ELECTRICAL WORLD for Oct. 13, 1888, and a full description of the Western Union plant in New York may be found on pages 225, April 14, 1883; 67, Feb. 11, 1888, and 79, Feb. 18, 1888. A description of the dynamo electric plant installed in the New York office of the Postal Telegraph Company may also be found on page 65 of THE ELECTRICAL WORLD issue of Aug. 18, 1888.

The economy effected by this change is readily apparent when it is remembered that each cell requires a space on strong shelving of 7 × 7 × 11 inches. Thus the 25,000 cells displaced, if set side by side in one long row would occupy nearly 15,000 feet of shelving. Presuming that an ordinary double store room is 100 feet deep by 60 feet in width, in the clear, a line of supports running the entire length of the room and supporting six set of shelves would hold but 900 cells, thus necessitating the erection of 28 lines of supports for the accommodation of 25,000 cells, which would fill the room after allowing the necessary space required in handling the cells. The rental of such a room in a convenient location would be at least $3,000 per year. The first cost of a gravity cell set up averages, when bought in such large quantities, fifty cents each, while the average cost of maintenance is one dollar per cell per year. Thus to set up a battery plant of 25,000 cells would cost about $13,000, with a yearly expense account added of from $25,000 to $30,000.

The entire expense of maintaining the present dynamo electric plant, including labor, rent, interest, improvement and depreciation will not exceed $7,000 per year—a net gain of $18,000, while the cells displaced will be utilized in various small town offices without further loss.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, Feb. 22, 1890.

The United Electric Light and Power Company, which consists of the local Westinghouse lighting interests, has secured offices in the *Times* building, its quarters being those formerly occupied by the World's Fair committee.

Mr. C. B. Seabury, who has had a long experience in the introduction of boiler coverings, etc., has now been connected for some little time with the H. W. Johns Manufacturing Company, of 87 Maiden Lane, in the work department for asbestos, steam pipe and boiler covering, fire proofing, roofing, etc.

Schaffer & Budenberg, 40 John street, New York, are pushing their tachometers and speed indicators in the electrical industries. Both the portable and the stationary tachometers are useful in electrical work. A number are now in use by electric light companies, with much advantage in economy and in perfection of light supply.

The American Leather Link Belt Company, of 46 and 48 Ferry street, have, as already noted in your columns, supplied the Chicago Auditorium recently with an outfit of belts for running the magnificent electric light plant there, the largest in the world of the "isolated class." The order was for eight 15-inch leather link belts, one 11-inch, two 9-inch and one 6-inch.

The "Ajax" Switches.- Mr. C. S. Van Nuis, of 18 Cortlandt street, the manufacturer of the Ajax switches, has issued a neat little folder calling attention to their merits for all heavy electric lighting, railway and power circuits. The object sought was the production of a switch which would carry its maximum load without heating, and break a current of 10 per cent. overload without spark or burning of the points of contact.

The Peckham Street Car Wheel & Axle Company, 239 Broadway, have issued a circular calling attention to the desirable features of their specialties in the field of electric railway work, including the Peckham cantilever motor truck, the non-oscillating motor truck and the pedestal motor truck; not forgetting Peckham's patent interchangeable elastic motor wheels and his fibrous steel motor axles. Mr. Peckham has made the later evolutions of street railway work his special study, and hence has produced these and other meritorious inventions that are being so highly appreciated everywhere.

Electricty at Church Fairs.—At the annual fair of the Lee Avenue Congregational Church, Brooklyn, one feature was an electric tree, designed by W. T. Knox. It was an evergreen covered with dozens of tiny incandescent candles, which lighted up in order. Over the tree was a Japanese fan and a large star containing at each point small lights. At the foot two stuffed owls were arranged so that electric lights appeared in their glass eyes. The whole arrangement, which was decidedly original, was run with a J. H. Mason primary battery, which gave great satisfaction. Mr. Knox superintended the working of his model himself.

The New York Edison Company's Capital.—The Edison Electric Illuminating Company has filed with the Secretary of of State the record of its second increase of capital stock. Originally the corporation was capitalized at $1,000,000; Jan. 19, 1886, the capital was increased to $2,500,000, and Jan. 20, 1890, to $4,500,000. The record shows that the capital actually paid in was $1,548,500 in cash,

$950,000 was granted for licenses under patents, and $1,500 for services rendered. The liabilities are $313,000, $280,000 of which is secured by mortgage, and $33,000 unpaid expenses and uncompleted accounts. The certificate is signed by George Foster Peabody as president and by S. B. Eaton as secretary.

The Electrical Subway Case.—Argument was to have been heard on Feb. 21 before Judge Barrett in Supreme Court Chambers, this city, upon the Manhattan Electric Light Company's motion to render permanent the temporary injunction granted on Feb. 19 by Justice Patterson, restraining Mayor Grant and the Board of Electrical Control from modifying the existing contract between the city and the Consolidated Telegraph and Electrical Subway Company, and from making a new contract with the Standard Electrical Subway Company. Owing to the engagements of Wheeler H. Peckham, counsel for the Standard Company, and of other lawyers interested in the contest now pending, Elihu Root, counsel for the Manhattan Company, consented to an adjournment of the motion until Feb. 26.

W. H. Gordon & Co., electric light and power supplies, are pushing the Ellis oil filter, and speak of the sales as being most satisfactory. A few of the recent purchasers are the West End Street Railway Company, of Boston; Charlestown Gas Company, of Boston; The Lee Electric Company, of Lee, Mass.; Middletown Electric Light and Power Company, of Middletown, N. Y; Washington Navy Yard, Washington, D. C,, and others. A number of the recent sales were made after placing them in competition with other filters. The fact that the Ellis filter has invariably been accepted in competitive trials justifies faith in the appliance. The company are figuring with a number of buyers for Simplex wire, both line and rubber-covered. Porcelain cut-outs, and incandescent snap switches are meeting with a ready sale, and orders should be sent in early to take their relative position. Their fuse wire is claimed to be the best made, being determined on scientific principles, and it is having an excellent sale.

National Meter Company.—Every other illuminant pales before the electric light. That this is so, is well instanced by the demands made by the parties in the rural districts who use their own gas machines to have their gas converted into electricity. With a view to meeting these demands, the National Meter Company, of 252 Broadway, and Mr. O. Tirrill, proprietor of Tirrill's equalizing gas machine, of 39 Dey street, New York, have recently effected a combination which will bring joy to the hearts of our brethren in the country. The combination consists in a Tirrill equalizing gas machine, a Nash gas engine and a Perret dynamo. The arrangement is automatic from first to last, the light is much steadier than gas, to say nothing of its other advantages, and a long felt want is filled. The dynamo used is the Perret automatic compound machine, the efficiency of which could not be better illustrated than by its many recent combinations with small engines of this kind, where the power supplied is very limited as compared with the results to be attained. A twenty-five-light plant of this description is now in very successful operation at 39 Dey street New York.

The Hall Signal Company, of 50 Broadway, are putting on the market a new automatic electric signal system for railways, devised by Mr. T. S. Hall, who is so well known in this field. This new Hall system is operated by a closed circuit. When no train is in the block section, the signal is held at "safety" by the current, and any derangement of the latter allows the disc to automatically move to the danger position. In the trial on the Boston & Albany road, from the time of its installation on May 30, 1888, to the present, and being used as a positive block signal, it has never got out of order, caused an unnecessary stop, or shown safety when danger existed, thus making a perfect mechanical record. By reason of this the road is now extending the system, and will soon have 33 miles, the whole line from Riverside to Worcester, double track, equipped with it, the sections being overlapped. The New York, New Haven & Hartford road now has in regular block service seventy-four of the new Hall signals, protecting all station yards (also the bridge over the Connecticut River, at Windsor Locks) dangerous points and switches on the main line between New Haven and Springfield, 62 miles. This road has sixty-one Hall highway crossing, station and drawbridge bells in use at various points on the New York, Hartford & Shore Line divisions. W. T. H.

NEW ENGLAND NOTES.

Branch Office of The Electrical World,
Room 8, Cook Building, cor. Franklin and Congress Sts.
Boston, Feb. 22, 1890.

The Tropical American Telephone Company, Limited, reports large orders from all its sub-companies.

The Edison Electric Light Company, of Fall River, Mass., have delared a dividend of one and a half per cent.

Mr. D. A. Andrews, of Pettingell, Andrews & Company, of Boston, has gone to Washington, D. C., for a short vacation.

The Holtzer-Cabot Electric Company, of Boston, have declared a dividend of four dollars per share, payable Feb. 15.

The Wainwright Manufacturing Company of Massachusetts have sold a 150 h. p. heater to the Oxbridge and Northbridge Electric Company, at Oxbridge, Mass.

Protection from Fires.—The Southern New England Telephone Company are making experiments with a safety fuse with a view to its adoption, to be placed on all wires entering buildings.

Lowell, Mass.—At the first annual meeting, held this week, of the Middlesex Electric Light Company, Lowell, under the law of Massachusetts, it was voted to increase the capital stock from $150,000 to $300,000.

Mr. Warren S. Hill has gone to pay a short visit to relatives in Florida, and will be gone till about the first of March. Mr. Hill has been an assiduous worker for the past year, and is in much need of some rest.

The Woonsocket Electric Machine and Power Company, by a bill in the Senate, from the Committee on Mercantile affairs, has been authorized to erect poles and wires and furnish electric light and power in Blackstone.

Newton, Mass.—A large area of new land in the Hunnewell avenue section of Newton, is about to be opened under syndicate operations. The plan contemplates extending the electric railway from Oak square, Brighton, to Nonantum square at Newton.

The Westinghouse Electric Company report having sold a 400-light incandescent plant to Washburn & Moen Manufacturing Company, Worcester, Mass., and a 400-light incandescent plant to the Springfield Emery Wheel Manufacturing Company, at Bridgeport, Conn.

Hartford, Conn.—Mr. Harry Johnston and Mr. George Johnston have been called to Vermont owing to the serious sickness of their father. In their absence Mr. Fred Lewis, of New Haven, has taken charge of the station, and the Messrs. Johnston can at least be confident that it is in safe hands.

Electric Welding for Use on Board U. S. Cruisers.—The naval officers composing the board organized by the Secretary of the Navy to report upon the adaptability of the Thomson electric welding process for work on the cruisers and the men-of-war met this week at the works of the welding company at Lynn, Mass.

Mr. F. E. Pettingell, owing to a somewhat protracted sickness and the unprecedentedly busy season, has been prevented from making his usual visit to his many friends through New England and other States. Mr. Pettingell hopes, however, before long to be able to get away so as to let his out-of-town friends see that he is still as much of a pusher as ever.

Northampton, Mass.—The newly elected directors of the Northampton Electric Light Company at the recent meeting unanimously elected A. McCullum president, and C. H. Pierce secretary and treasurer. New alternating machines have been ordered to replace the old dynamos running on the direct system. Five per cent. bonds to the amount of $25,000 will be issued.

Canton, Mass.—The Blue Hill Electric Company, using the Westinghouse system, has at last secured the contract for the city lighting of Canton, Mass., and the North American Construction Company have now a gang of men at work in that city. The street lighting contract calls for 35 arc lights and 70 incandescent lamps, but provisions will be made for commercial lighting as well.

Mr. Charles A. Stone, recently of Howard & Stone, Boston, agents for the C. & C. motor, has joined the Massachusetts Electrical Engineering Company, as one of the managers. The company has now got fairly started, and is doing a large testing business in various branches, and consulting business is beginning to come in. Webster & Stone are the managers, and their headquarters is at 4, Post Office Square.

The Gethins Electric Manufacturing Company have just sold 300 of their improved Gethins gravity battery to the city of Lowell, Mass., for fire alarm work. Orders have also been received for 50 for Beverly, Mass., and 50 for New Bedford, Mass. Enquiries and orders are coming in from all over the country, and the Gethins battery is rapidly gaining favor, as a reliable gravity battery, which performs to the letter all that is claimed for it.

Mr. David W. Dunn, of the Thomson-Houston Electric Company, has been temporarily transferred to the Philadelphia office, where he will assist Mr. Mullen of that city. While Mr. Dunn's friends are all sorry to lose him even for a time, they wish him all success in his new field, and a speedy return. Mr. Dunn will be much missed by his numerous friends not only in Boston, but all through Connecticut, the territory with which he was most familiar.

Plantsville, Conn.—The annual meeting of the stockholders of the Connecticut Motor Company was held at the Plantsville factory on Feb. 4. The treasurer's report showed very satisfactory business to have been done during the five months subsequent to the increase of capital stock, with a steady rise in number of sales month by month. The sales for January alone have almost doubled the company's business. The officers elected were: President, R. E. Dunston; treasurer, S. Blakeslee, Jr.; secretary, J. R. Staff.

The Jordan Train Lighting Company, with temporary quarters at 133 Oliver street, has been incorporated under the laws of the State of Maine, with a capital stock of $500,000. The following officers were elected: President, W. S. Hill; Treasurer, John F. Wood; general manager, L. F. Jordan; Directors, A. L. Babbage and J. S. Chamberlain. The purpose of the company is the general manufacture of electrical goods, with specialties of Jordan's mast arm, train lighting system, couplers, and other devices of Mr. Jordan's.

The Tripp Manufacturing Company, of Boston, who are the sole manufacturers of the Tripp anti-friction bearings, which are meeting with unprecedented success amongst electrical engineers, have decided to remove from their old quarters at 34 India Wharf, and have taken a suite of elegant offices in the new New England Building, 180 Summer street. Their business is rapidly increasing and they now have a number of Tripp trucks in process of construction in their large and commodious factory on Commercial street.

The Intercontinental Telephone Company, Boston, operating in Venezuela, South America, are shipping large quantities of supplies, instruments, and telephonic material, to extend their system in Caracas, La Guayra, Valencia, and Porto Cabello. The multiple switchboard at Caracas, with 800 subscribers capacity, is full, and two new sections are about to be sent out to accommodate the applicants awaiting service. Seventy-five tons of iron poles, and over $10,000 worth of new material, is being forwarded by steamers sailing this month.

Mr. C. L. Edgar, general manager of the Edison Electric Illuminating Company, of Boston, sailed last Saturday for a two months' trip to Europe, for the purpose of making a thorough investigation of central station practices. Mr. Edgar's visit will extend to London, Paris, Berlin and Rome, but he will doubtless visit many other cities before his return. Mr. Edgar has worked hard and faithfully in Boston, and it is hoped that this trip will be of benefit to him, both in a business sense, and as a means of rest through change of scene.

Boston's Street Lights.—The board of aldermen has finally disposed of the question of admitting the Suburban Light and Power Co. to do business in this city. The committee of the whole board held two lengthy sessions yesterday, at each of which the question was fully gone into; and at the meeting of the board later in the afternoon the result of the committee's deliberations was made known. The board finally voted by seven to five to refuse pole rights, so that for the present the Suburban Company has suffered defeat. The Boston Electric Company has made a bid to light the streets for 40 cents a night, and will naturally secure the contract now, as the action of the aldermen has annulled the contract made between the Mayor and the Suburban Company. The Suburban Company, however, do not intend to take their defeat quietly, and have determined to carry the matter into the courts and make a vigorous fight to test its rights. A motion was filed in the Supreme Judicial Court yesterday by R. M. Morse, jr., for a writ of mandamus to compel the Board of Aldermen to grant it reasonable location for electric light poles. Meantime the Suburban Company are running a small temporary plant in Roxbury, with about 20 commercial lights, using the Waterhouse system, but these lights will be changed over into the new Westinghouse system as soon as the new dynamo can be started in the South Street station, and lines run to connect. They are also busy procuring rights on house tops from private individuals, in order to cover as much commercial lighting as they can obtain.

Surprise Party to Mr. Frank Ridlon.—A very pleasant surprise donation party was given by a number of Mr. Ridlon's friends of the Boston Electric Club last week, for the purpose of paying their respects to their beloved "pastor." The party consisted of Dr. Harriman, Messrs A. P. Wright, C. H. Holtzer, J. R. Magee, Mark Simonds, F. J. Boynton, F. S. Palmer, A. C. Shaw, Chas. Dutton, of New York; W. J. Denver, Walter Pettingell, Captain Ford, A. B. Griggs, H. H. Rice, of Lynn; W. A. Stiles, G. W. Adams, W. S. Key, H. B. Cram, T. J. Tormie, of the Boston *Globe*; John Post, Jr., H. M. Daggett, of Attleboro, Mass., W. P. Mahoney, and W. R. Johnston, of Newburyport. Neat cards of invitation were issued, and the gentlemen met at the rooms of the Boston Electric Club at 6:30 P. M. Messrs. Holtzer, Magee, Simonds, Boynton, Rice and Stiles acted as heralds, and Mr. Griggs was appointed to the responsible position of grand marshal. A special electric car was chartered for the occasion, and a fast trip was made, the heralds keeping up a lively tooting on their four-foot horns. Arrived at their destination a terrific blast on the horns in front of Mr. Ridlon's parlor windows announced to that gentleman, who was luxuriantly taking his ease before a bright wooden fire, that something unusual had happened. As soon as the door was opened the gentlemen filed silently in and deposited on the parlor floor as their donations several basketfuls of all conceivable vegetables, half a cord of fire wood, a box of slippers from a large and select circle of Mr. Ridlon's fair admirers, and other presents too numerous to relate. Mr. Ridlon was at once arrayed in a gorgeous gingham dressing gown, which threw Joseph's robe of many colors entirely into the shade, and which had in place of buttons a numerous assortment of "push buttons." A cap was also presented and placed on his head, which was likewise decorated with a push button, and then Mr. Ridlon was set at liberty to receive the gifts and congratulations of his friends. A box of cigars was presented with the cards of Messrs. Boynton, H. D. Stanley, L. J. Burnham and G. L. Manson enclosed, and Mr. Dutton in a touching speech presented Mr. Ridlon with a beautiful doll, which, on being taken out of its box, immediately addressed him as "papa." An elegant supper was then served in the dining-room, consisting of all kinds of cold viands and salads, and washed down by liberal potations of whatever the heart desired. It was well served by the club steward, and enjoyed by all. After supper, while Mr. Boynton presided, short and pithy speeches were made by Messrs. Boynton, Denver, Griggs, Stiles, Dutton, Shaw, Magee and Wright, while Mr. Ridlon excelled himself in a racy and humorous speech of thanks to all his friends. On the table prominent attention was called to the veritable cake presented by Mr. Simonds to Mr. Ridlon on the occasion of his inauguration as President of the Electric Club, in 1887. The evening was concluded with songs, recitations and stories, and many were the expressions of regret at ending so jovial an occasion as the members bade Mr. Ridlon an affectionate good night. Return was made on another special car, and as the hour was late and the roadway comparatively clear, a phenomenally quick run was made, though several stops had to be made, the distance of three and three-quarter miles being covered in eleven minutes, an average speed of about twenty and one-half miles an hour. A. C. S.

BUSINESS NOTICES.

Free Sites for Factories, and other liberal inducements to manufacturers, are offered by the East Chattanooga Land Company, whose advertisement appears in another column.

A. L. Bogart.—Errors were made in quoting prices in A. L. Bogart's full-page advertisement in the issue of Feb. 22. The burners No. 3a and No. 3b, "Iron Tips," should have been $1.10 each; and the 12-inch frictional machine for multiple gas lighting $75, not including a four-way switch.

Henry R. Worthington, of 86 and 88 Liberty street, has issued a handsome new catalogue of steam pumping machinery, independent condensers and water meters. It is a pamphlet of nearly 100 pages, abounding in illustrations and descriptions of plant of the character named.

Battery Cut-Out.—Attention is called to a simple device for disconnecting gas lighting batteries if accidentally grounded. It is cheap, sensitive, never needs watching, and has no clockwork to be kept wound. Terms furnished by the Electric Supply Company, of Syracuse, N. Y., No. 105 South Warren street.

The Ferracute Machine Company, of Bridgeton, N. J., make 120 kinds of foot and power presses and dies, and a full line of all other sheet-metal tools. Some of their presses are specially designed for electrical work, and should be obtained by parties needing them. The company's apparatus is all well built and reasonable in price.

The Ætna Machine Company, Warren, Ohio, received on Feb. 4 an order from Messrs. Westerman & Co., Lockport, N. Y., for a 550-h. p. engine to drive a train of rolls in their mills at Lockport; and on Feb. 10 an order from Mr. Ralph J. Wick, Treasurer of the Lancaster Iron Company, Lancaster, O., for a 550-h. p. engine to drive a train of rolls in the mills at Lancaster. This is the second engine sold to the Lancaster Company, and the third one to Mr. Wick.

The Midgley Wire Belt Company, of Beaver Falls, Pa., have just issued an "advance catalogue" of their products, principal among which are steel wire belting, cable, hose, etc. We have been favored with a sample of the wire belting, both new and after a year's use. From an inspection of both we should judge that a year's employment had not deteriorated the strength of the belt, but that, on the contrary, its adhesive qualities had been improved. Electric light station managers would do well to write for particulars and pamphlet.

Hine's Eliminator.—Of the merits of the Hine Oil, Grease and Water Eliminator, the advertisement of which will be found in our advertising columns, Prof. C. R. Richards, Pratt Institute, Brooklyn, writes as follows:

PRATT INSTITUTE, BROOKLYN, N. Y.
Jan. 14, 1890.

Hine Eliminator Company:

Gents: The 8-inch Eliminator which you put in for us last September, has operated very satisfactorily. The oil contained in the exhaust from three engines is entirely separated out, and the condensed steam, after passing through the heating system, is returned to the feed water tank without a trace of oil discernible.

Yours, C. R. Richards,
Director Mechanical Arts Department.

A Letter from Dr. Johnson (electro-therapeutist) which speaks emphatically:

Perry, Ia., Dec. 16, 1889.

Jerome Kidder Manufacturing Company:

Respected Sirs: Yours of this morning received, stating that you have shipped battery and electrodes as directed. I appreciate your promptness.

Surely you can term me an old patron, for I have never used any other (only occasionally, and in case of an emergency, owing to not having my visiting battery, which is a Kidder No. 1). I also possess one of your superior cabinet galvanic and faradic batteries combined, and I do not wish or ask for any better apparatus, believing, in all candidness, that they have no superior—no not an equal. I have used your apparatus and instruments for nearly fourteen years, and I would have no other. It is quality, either in medicine or electrical goods, that I desire. Yes, I am a true and tried disciple of Jerome Kidder. Sincerely thine,

T. F. Johnson.

Owing to the pressure on our columns, the Patent Record has been omitted this week.

Franklin S. Carter. Charles M. Wilkins. E. Ward Wilkins.

TRADING AS

PARTRICK & CARTER,

MANUFACTURERS AND DEALERS.

ELECTRICAL SUPPLIES,

Sole Proprietors of the Patent Needle Annunciator,

ESTABLISHED 1867. 114 SOUTH SECOND STREET, PHILADELPHIA, Pa., March 8, 1890.

NOTICE TO THE TRADE.

For the convenience of the trade at points far distant from Philadelphia who desire to use our goods more extensively, but are deterred from doing so on account of the transportation charges and delay in transit, we have arranged with the parties named be'ow to carry a stock of our Patent Needle Annunciators, Alarms, Bells, Disque Leclanche Batteries and a full line of Electrical Supplies of our manufacture. When n want of the PARTRICK & CARTER Instruments and Supplies, you can obtain them by applying to the firms named at very near the Philadelphia Trade Prices, and effect a great saving in time, freight charges, etc.

SOUTHERN DISTRICT TELEGRAPH AND ELECTRIC CO., Birmingham, Ala.

L. W. WOLFE & CO., Omaha, Neb.

UNITED EDISON MFG. CO., Chronicle Building, San Francisco, Cal.

NORTHWESTERN ELECTRIC SUPPLY AND CONSTRUCTION CO., Seattle, Wash.

The above-named firms will cheerfully answer any inquiries regarding prices, etc., of our goods.

Very respectfully,

PARTRICK & CARTER.

THE NEW

EDISON-LALANDE BATTERY

MANUFACTURED UNDER AUTHORITY OF

Thomas A. Edison.

Primary Batteries for Telegraph "Mains" and "Locals," Electro-Motors, Electro-Plating, Telephone Transmitters, Electro-Medical Instruments, Annunciators and Burglar Alarms, and all Classes of Closed and Open Circuit Work.

Further Particulars and Information Furnished upon Application.

EDISON MANUFACTURING COMPANY,

JAMES F. KELLY, Agent,

19 DEY STREET NEW YORK.

Minneapolis. St. Paul. St. Louis.

THREE MORE LARGE CITIES FALL INTO LINE.

All the lines in Minneapolis and St. Paul, and between these two cities, comprising 200 miles of track, are to be equipped on the Sprague Electric System.

[*Statement of Mr. Thomas Lowry, President of the Minneapolis Street Railway.*]

NEW YORK, Feb. 19, 1890.

"I have to-day closed contract with the Sprague Electric Railway and Motor Company for the electrical equipment of the street railways in Minneapolis and St. Paul, and between these two cities.

(Signed) "THOS. LOWRY, President."

St. Louis follows with an order for sixty-eight car equipments for the Lindell Street Railway in that city.

TOTAL NUMBER of STREET RAILWAY MOTORS CONTRACTED for SINCE JAN. 1, 1890 - 810

SPRAGUE ELECTRIC RAILWAY & MOTOR CO., 16 & 18 Broad St., N. Y.

Rialto Building, Chicago, and all commercial centres.

CONTRACTORS and BUILDERS.

PROTECTION

AGAINST CLAIMS FOR

ACCIDENTS

TO

Their own or other Contractors' Workmen and the outside Public.

CHIEF OFFICES FOR UNITED STATES,

No. 71 KILBY STREET, BOSTON.

ENDICOTT & MACOMBER, Managers.

EMPLOYERS' LIABILITY ASSURANCE CORP. (Lim.), of LONDON, ENG.

ENDICOTT & MACOMBER, Boston, Mass., Gen'l Managers U. S. Branch.

Sam'l Appleton, 28 Central St., Boston, Gen. Agt. for Mass., N. H., Vt. and R. I.; Kirby & Dwight, 51 Cedar St., New York, Gen. Agt. for N. Y.; Tattnall Paulding, 416 and 420 Walnut St., Philadelphia, Pa., Gen. Agts. for Pa.; Geo. A. Gilbert, 226 and 228 La Salle St., Chicago, Gen. Agt. for Illinois.

CHARLES MUNSON, PREST.
FRANK G. MOSS, SEC'Y & TREAS.

Charles Munson Belting Co

MANUFACTURERS OF

EAGLE and DYNAMO BELTING.

PITTSBURGH. NEW YORK. **CHICAGO.** SAN FRANCISCO. NEW ORLEANS.

28, 30, 32, 34 & 36. S. CANAL ST.

NEW YORK, 34 DEY STREET.

THE PAISTE SNAP SWITCH

—FOR—

INCANDESCENT WORK.

Recognized as the Best, Simplest and most Durable Circuit Breaker in existence.

H. T. PAISTE,

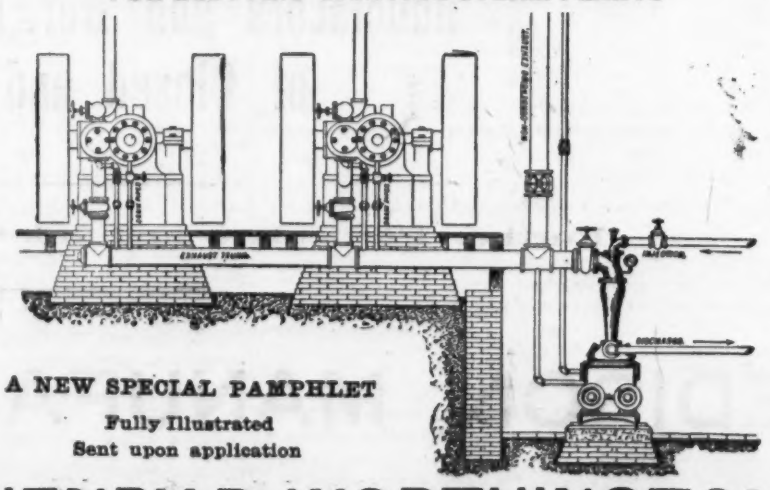
Twelfth and Market Sts.,

PHILADELPHIA, PA.

Kept in Stock and for Sale by all Prominent Supply Houses.

THE WORTHINGTON INDEPENDENT CONDENSER

FOR ELECTRIC LIGHTING STEAM PLANTS



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